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ALKYL-ARYL LEAD COMPOUNDS. ANTI-KNOCK STUDIES

By HENRY GILMAN, O. R. SWEENEY AND J. E. KIRBY

From the Departments of Chemistry and of Chemical Engineering at Iowa State College.

Accepted for publication July 17, 1928.

INTRODUCTION

Tetra-ethyl lead is at present the most widely used anti-knock reagent. However, unsaturated and aryl groups apparently increase the anti-knock effectiveness of various gasolines. It is for this reason, in part, that an added emphasis is being placed by some on the superior qualities of gasoline obtained by cracking processes. If this idea is sound, then it is reasonable to expect that organolead compounds formed by replacing some or all of the saturated ethyl goups in tetra-ethyl lead by unsaturated or aryl groups should be more effective anti-knock agents than tetra-ethyl lead. Accordingly, a study is being made of such compounds².

The compounds reported here are the n-butyl, iso-butyl, sec.-butyl and tert.-butyl, triphenyl leads. The preparation of tert.-butyl triphenyl lead is unusual. Hitherto, "no lead compound containing a tertiary hydrocarbon group has been prepared. All the attempts have resulted only in a reduction with deposition of metallic lead". Related reduction reactions were observed in the first attempts to prepare tert.-butyl triphenyl lead. For example, when triphenyl-lead bromide was added to tert.-butyl-magnesium chloride, a mixture resulted from which only the highly interesting triphenyl-lead (or hexa-phenyl di-lead) could be isolated. However, by reversing the order of addition by adding the Grignard reagent to triphenyl-lead bromide, the desired compound was obtained. With tert.-butyl-magnesium chloride in excess, the Grignard reagent may act as a reducing agent according to the following reaction:

$$tert.-C_4H_0MgC1 + (C_6H_5)_3PbBr \Rightarrow C_4H_8 + C_4H_{10} + (C_6H_5)_3Pb + MgC1Br$$

One of the most recent and leading accounts of petroleum and its products is by Burrell, Ind. Eng. Chem., 20, 602 (1928).

[&]quot;This is part of a more general study of organolead compounds, particularly with a view to their application in the treatment of cancer and some related plant diseases. See, Gilman and Robinson, J. Am. Chem. Soc., 49, 2315 (1927) and 50, 1714 (1928).

^{&#}x27;Calingaert, "Organic Compounds of Lead," Chemical Reviews, 2, 43 (1926). This is the most recent and authoritative treatise on organolead compounds. Prior to the preparation of tert.-butyl triphenyl lead, Dr. Balassa prepared di-tert.-butyl-diphenyl lead in this Laboratory.

One of the general methods for the large-scale production of tetra-ethyl lead involves the use of the Grignard reagent.

Gilman, Sweeney and Beaber⁵ prepared tetra-phenyl lead in large quantities by means of the Grignard reaction and tested its anti-knock properties and its solubility in nitrobenzene, inasmuch as such nitro compounds have distinct anti-knock properties and were for a time sold as anti-knock agents. Their comparative tests indicated that tetra-phenyl lead had distinct and promisingly superior qualities. The compounds described in the present report are, however, being tested with a series of related compounds by another method in a comprehensive study concerned with the correlation of chemical constitution and anti-knock effectiveness. By this method, organolead compounds that are solid at room temperatures and sparingly soluble in gasoline cannot be tested with any great reliability. However, related organolead compounds now being tested and having a lesser number of aryl groups indicate that the anti-knock effectiveness increases somewhat with the branching of radicals.

EXPERIMENTAL

The tetra-phenyl lead used in these studied was prepared according to the method of Pfeiffer and Truskier⁶. Subsequently, Gilman and Robinson⁷ devised improved directions for its preparation from the Grignard reagent and lead chloride.

Triphenyl lead bromide was prepared according to the method of Grüttner⁸. It is essential that pure pyridine be used in this low temperature (-50°) bromination. With the use of pure pyridine and in runs one-half the size of that described by Grüttner, the yields were 80% or better.

n-Butyl-Triphenyl Lead. C₄H₉Pb(C₆H₅)₃.—A solution of 0.08 mole of n-butylmagnesium bromide was prepared from 11 g. of n-butyl bromide and 1.95 g. of magnesium. This solution was diluted to about 250 cc. with dry ether and then 20 g. (0.04 mole) of triphenyl lead bromide was added in small quantities. A slight heat of reaction was noticed. The reaction mixture was stirred and gently refluxed about one and one half hours and then hydrolized by pouring on iced ammonium chloride solution. A little ammonium hydroxide was added and the entire mixture was filtered with suction to remove a small quantity of dark insoluble material. The ether layer was removed, dried over sodium sulfate, and then concentrated. The yellowish paste that resulted became solid when rubbed with alcohol. It was washed twice with 95% alcohol and air-dried to constant weight. The yield was 12.7 g. or 66.5% of the theoretical amount. When once recrystallized from 95% alcohol the white crystals melted sharply at 47°.

Doctorate Thesis of N. J. Beaber, Iowa State College, 1925. In the article by T. A. Boyd, "Quantitative Effects of Some Compounds in Detonation in Internal Combustion Engines" (International Critical Tables, volume 2, pages 162-163), there is no mention made of nitro compounds in his list of some anti-knock compounds. Also, the tetra-phenyl is rated there as about 50% per mole, as effective as tetra-ethyl lead.

^{&#}x27;Pfeiffer and Truskier, Ber., 37, 1123 (1904).

¹Gilman and Robinson, J. Am. Chem. Soc., 49, 2315 (1927).

⁸Grüttner, Ber., 51, 1298 (1918).

Analysis.—All of the organolead compounds reported here were analyzed for lead by the method described recently by Gilman and Robinson⁹. Calc. for C₂₂H₂₄Pb: Pb, 41.82%. Found: Pb. 41.46 and 41.52%.

Iso-Butyl Triphenyl Lead.—The procedure was the same as the one just described for the preparation of n-butyl triphenyl lead. The yield was 15.4 g, or 80.6% of the theoretical amount. When twice recrystallized from alcohol the compound is obtained as fine needles melting sharply at $68-68.5^{\circ}$.

Analysis.—Calc. for $C_{22}H_{24}Pb$: Pb, 41.82%. Found: Pb, 41.38 and 41.21%.

Sec. Butyl Triphenyl Lead.—This compound was prepared according to the directions for the preparation of the two preceding compounds. The yield was 12.3 g. or 64.4% of the theoretical amount. After one recrystallization from 95% alcohol the compound melted sharply at 84°.

Analysis.—Calc. for $C_{22}H_{24}$ Pb: Pb, 41.82%. Found: Pb, 41.59 and 41.43%.

Tert.-Butyl Triphenyl Lead.—A solution of 0.2 mole of tert.-butyl-magnesium chloride was prepared according to the improved directions described recently by Gilman and Zoellner¹⁰ from 18.4 g. of tert.-butyl chloride and 5 g. of magnesium turnings. To this solution was added 19.5 g. of triphenyl lead bromide. The heat of reaction was very slight and the solution had a yellowish color. The insoluble material obtained subsequent to hydrolysis with iced ammonium chloride and ammonium hydroxide was filtered by suction and washed with ether. The yellow colored ether layer and washings were dried over sodium sulfate and then concentrated to give a yellowish solid that weighed 8.6 g. and melted unsharply at 95°. Recrystallization from alcohol and then from benzene gave yellow crystals that melted unsharply and with decomposition at 150°.

The mother liquor and washings were diluted with alcohol and on standing two distinct types of crystals separated: flat, white plates and star-like clusters of yellow needles. These crystals were filtered, dried and then carefully separated by hand. The white crystals correspond closely with triphenyl lead obtained by Krause and Reiszaus¹¹ who have described triphenyl lead as crystallizing from benzene in light yellow crystals which begin to melt at 155° and are completely melted at 225°, the melt being colored black with free metallic lead. These crystals contain 1.5 molecules of benzene. When the benzene is replaced by alcohol a compound is obtained which is nearly white and contains no solvent of crystallization. Their compound gave a green coloration when dissolved in benzene and treated with alcoholic silver nitrate. The white compound obtained in our experiment begins to decompose at 148° and at 220-222° breaks down to a gray mass. It also gives the green color-test with alcoholic silver nitrate.

^oGilman and Robinson, J. Am. Chem. Soc., 50, 1714 (1928).

¹⁰Gilman and Zoellner, ibid., 50, 425 (1928).

[&]quot;Krause and Reiszaus, Ber. 55, 888 (1922).

This color test was found to be negative with n-butyl triphenyl lead and with triphenyl lead bromide.

Analysis.—Calc. for C₁₈H₁₅Pb: Pb, 47.26%. Found: Pb, 47.33%. The yellow crystals were not identified. They melt at 95-97° to an opaque yellow mass, with a red color which appears at 110°, turning to black at 112°. These crystals also give the silver nitrate color test.

In a second experiment the order of addition was reversed, the tert.-butylmagnesium chloride being added slowly to 10.4 g. or 0.02 mole of triphenyl lead bromide suspended in ether. The Grignard solution was prepared from 4.6 g. or 0.05 mole of tert.-butyl chloride, 1.22 g. of magnesium turnings and 70 cc. of ether. In order to minimize the supposed reducing reaction of the Grignard reagent, only one-half of this RMgX solution was added; and, inasmuch as the yield of tert.-butylmagnesium chloride was only about 65%¹⁰ the effective quantity of Grignard reagent added was less than the theoretical amount necessary for a complete reaction. This undoubtedly accounts in part for the low yield and for the difficulty encountered in the separation of the reaction product from unaltered triphenyl lead bromide.

During the addition of the Grignard solution a yellow color appeared. The mixture was hydrolyzed with iced ammonium chloride and filtered. On concentrating the yellow ether layer by evaporation a yellow solid resulted, and this underwent decomposition on heating with alcohol. This material was not further investigated. The residue from filtration was extracted with several small portions of hot alcohol, and on cooling white needles separated. Repeated crystallization from alcohol gave glistening needles that melted sharply at 150-150.5°. When mixed with a sample of triphenyl lead bromide (melting at 157°) the melting point was depressed to 130°.

Analysis.—Calc. for $C_{22}H_{24}Pb$: Pb, 41.82%. Found: Pb, 41.60 and 41.69%.

SUMMARY

The four butyl triphenyl leads have been prepared from the appropriate Grignard reagent with triphenyl lead bromide. Some triphenyl lead or hexaphenyl di-lead was obtained in connection with the preparation of tert.-butyl triphenyl lead. This tert.-butyl derivative, apart from its value in anti-knock studies, is the first reported organolead compound having a tertiary radical attached directly to lead.

THERMAL CONDUCTIVITIES OF GLASSES TRANSMITTING ULTRA-VIOLET LIGHT

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From the Department of Physics, Iowa State College

Accepted for publication September 15, 1928

Increased knowledge of the beneficial therapeutic effects of ultraviolet light upon living organisms has in recent years led to the development of a number of glasses which transmit ultra-violet light more or less completely. Among them may be mentioned Quartz-lite, Corex, Vita glass and Helio glass. It is evident that if any of these are to replace the window glass now being used, they must be very poor conductors of heat, for otherwise we might pay dearly for the benefits secured by the use of these glasses because of the greater amount of heat they would allow to escape from a room by conduction. It therefore becomes important to determine the thermal conductivity of the glasses under consideration.

Since the thermal conductivity of glass is very low, it is impossible to get reliable results by the use of the ordinary laboratory method of determining conductivity. The method here resorted to was originally due to Christiansen. If a slab of a given material of thickness d, with parallel faces each of area A, has its opposite faces kept at temperatures t₁ and t₂. respectively, the quantity of heat, Q, which will pass by conduction through the slab from one face to the other in a time T is directly proportional to the area of the face, the difference in temperature, and the time, and inversely proportional to the thickness.

Then $Q = \frac{k A(t_2 - t_1) T}{d}$

In this expression k is a constant known as the thermal conductivity of the substance.

If two flat plates are placed in contact, face to face, and a steady flow of heat is established between them, perpendicular to the broad face, the heat Q which passes in time T is

$$\begin{aligned} \mathbf{Q} = & \frac{\mathbf{k_1} \ \mathbf{A} \ (\mathbf{t_2} - \mathbf{t_1}) \ \mathbf{T}}{\mathbf{d_1}} = \frac{\mathbf{k_2} \ \mathbf{A} \ (\mathbf{t_3} - \mathbf{t_2}) \ \mathbf{T}}{\mathbf{d_2}} \\ \\ \text{or} \ & \frac{\mathbf{k_1}}{\mathbf{k_2}} = \frac{\mathbf{d_1}}{\mathbf{d_2}} \ \cdot \ \frac{(\mathbf{t_3} - \mathbf{t_2})}{(\mathbf{t_2} - \mathbf{t_1})} \end{aligned}$$

This means that the ratio of the conductivities is given by the ratio of temperature differences and thicknesses. The actual quantity of heat need not be measured. If k2 is the conductivity of the standard of comparison, k_1 may be determined if we have the thicknesses and temperatures given.

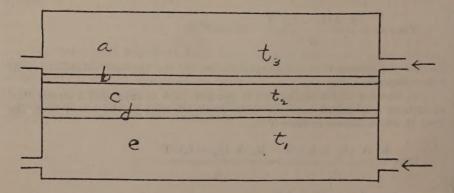
In the figure a is a steam chest through which live steam is passed, b is a layer of a substance whose thermal conductivity is known, c is a copper plate into which a thermometer is inserted to get the temperature t_2 , t_3 is the temperature of the steam, t_1 that of the water, d is the test material, and e is a water chest through which cold water is passed.

The conductivity of bakelite which was used for layer b may be taken as 0.00037 c.g.s. units. Glycerine was placed between any two consecutive layers to insure good thermal contact. Steam and water must be passed continuously for two hours. The copper plate, c, has a very high conductivity and the temperature gradient through it may be neglected.

The results obtained for the thermal conductivities were as follows:

Kind of Glass	Thermal Conductivity
Quartz-lite	0,000481
Corex	
Helio glass	0.000565
Vita glass	
Plain window glass	

Ordinary window glass does not transmit ultra-violet light. Experiment shows that it is a better conductor of heat than the other glasses tested. There are therefore at least two reasons why the window glass now being used should be replaced by other glasses; first, because the glass substitutes transmit some ultra-violet light; and second, because they allow less heat energy to escape by conduction.



STUDIES IN HOME CANNING*

III. Heat Penetration in Meats and Vegetables Processed in Glass Containers**

GAIL M. REDFIELD, P. MABEL NELSON AND GERTRUDE SUNDERLIN

From the Department of Foods and Nutrition, Iowa State College

Accepted for publication Sept. 15, 1928.

This work was undertaken as part of a study (26) (27) to formulate more accurate time tables than those available at present for the canning of the non-acid vegetables and meats in the water bath and pressure cooker under home conditions.

An enormous literature relating to the canning of food products, stimulated by the need for improved technique, has been developed in the last few years. Most of the experimental work has dealt with phases other than the rate of penetration of heat into jars, probably because of the difficulty of securing an exact record of the temperature of the interior of the jar and of the retort during processing.

Earlier experiments as those of Belser (5) showed, by the use of maximum thermometers in the jars, the maximum temperature attained in a given time, in some of the common fruits and vegetables. Beveridge and Fawcus (6) used thermometers for a study of the heat penetration in meat canned in tin.

The work of Kochs and Weinhausen (20) in Germany was similar to that of Belser. As the original of their work was not available, only the comment of Bigelow, et al (9), on this work can be given. It is as follows:

"In 1906 Kochs and Weinhausen gave the results obtained in a study of heat penetration in tin cans and glass and earthenware jars. Maximum thermometers of special construction were used and were held in position by being fastened to the side of the container. The results, therefore, gave only the maximum temperature attained at the center of the can and gave no information regarding the temperature at various intervals. The results are of little value and the work was quite crude, but it is of interest as pointing to a recognition of the necessary of information on the subject."

Later thermocouples were used for the study of heat penetration by Bovie and Bronfenbrenner (11). They undertook the problem of determining the rate of heat transfer from the outside toward the center of cans of food, during the process of cooking and sterilization, as affected by the variations of the autoclave, temperature, size of can and viscosity of the food.

^{*}The data in this paper are taken in part from a thesis submitted by Gail M. Redfield in partial fulfillment for the degree of Master of Science, Iowa State College.

^{**}Funds furnished through Ball Brothers Company, Muncie, Indiana.

Thompson (28) determined, by means of thermocouples, the temperature-time curves when cans are subjected to various temperatures in hot water, steam, cool air and cool water. He used fruits and vegetables in order to get as great a variety of conditions as practicable. He found that those products requiring a large amount of free liquid to fill the cans permit considerable convection currents and those requiring no liquid permit practically none. Ball (2) (3) made extensive studies of the mathematical relationships involved in heat penetration and sterilization of canned foods.

A summary of the findings of Bigelow and his coworkers (9) and of Magoon and Culpepper (21) (22) will be given, as the result of their work has the most direct bearing on this problem.

Bigelow, et al, found:

1. That heat penetration is most rapid in products that consist of or are surrounded by water, or a thin syrup or brine.

2. That products as peas, which consist of small round particles that are not cooked to pieces, permit the movement of heat by means of

convection currents almost as quickly as water.

3. That products which soften when heated and packed together, and products which are cooked to pieces during the process, make the solution somewhat viscous and retard heat penetration. If the pieces of insoluble material are somewhat larger like beets and large plums they delay the heating of the liquor, which does not reach retort temperature until the pieces are heated to the center.

4. That there appears to be no appreciable difference in the heat penetration of cans processed under water and those processed in dry steam

if the conditions are otherwise the same.

5. That the temperature is found to be the same in all parts of the retort.

6. That the heat penetration of canned foods is governed largely by

the freedom with which convection currents are formed.

7. That the maximum heat penetration of canned food is that of water or perhaps slightly less. The minimum heat penetration is that of a body consisting largely of water, but in which the water is distributed in minute cells that entirely prevent convection.

Magoon and Culpepper (21) (22) showed:

1. That the factors affecting the rate of change of temperature at the center of the can are the diameter of the container, the conductivity, thickness and radiative power of the walls, the temperature conductivity, and mobility of its contents, and the temperature, conductivity and movement of the medium surrounding it.

2. That in a can packed with material having an interspace filled with a free liquid as in string beans, the rate of change of temperature at the center of the can is very rapid, and in materials of a heavy or pasty nature, as in sweet corn, the rate of heat penetration is very slow unless

mechanical agitation is employed.

3. That the character of the pack and the composition of the material very largely determine the rate of change of temperature in the can.

4. That sodium chloride has very little direct effect upon the rate of change of temperature in the can. Dilute sugar solutions have only a small effect, concentrated solutions have a considerable effect in retarding

the rate of change. Materials of a viscous nature retard the rate of heat penetration.

- 5. That glass containers have a marked retarding effect upon the rate of rise in temperature in those materials in which there is a free liquid, as in string beans, but are of little importance in materials of a heavy consistency as sweet corn. Glass cools faster in air than tin, owing to its greater power of radiation.
- 6. That a proper temperature maintained for a length of time sufficient to prevent the subsequent development of the organisms causing the spoilage must be provided for first, but for the sake of the quality it should not be prolonged beyond the time essential to insure the keeping of the product and the safety of the food for human consumption.
- 7. That processing shall begin at the earliest possible moment after the preliminary treatment, otherwise time-temperature curves at the center of the can may actually fall during the first part of the processing period.
- 8. That with water, the rate of change of temperature at the center of the cans is very rapid when the external medium is water and very slow when it is air.
- 9. That in foods in which a free liquid fills the interspaces, the rate of change of temperature is very rapid, but while the maximum temperature is reached promptly, the maximum pressure is never reached during the ordinary processing periods, but continues to rise slowly as long as the high retort temperatures are maintained.
- 10. That in cans filled with material of a heavy consistency, the rate of change of temperature at the center of the can is very rapid at first and then becomes slower after the first few minutes. An equilibrium of pressure apparently is never reached, since in experiments where processing was continued for several hours, the pressure continued to rise as long as the retort temperature was maintained.

Other work of interest in this connection is that of Dugdale (14) (15), Bidault (7), Fellers (16), Fellers and Parks (17), Savage and Hunwicke (24) and Zavalla (29). Inasmuch as none of this work was as extensive

as that previously mentioned, it will not be reviewed.

The above findings pertain to commercial processing of food products. The results obtained, however, have a direct bearing on home processing of foods. The studies of heat penetration most nearly comparable to home conditions are those of Castle (12), Bauer (4), and Denton (13).

Bitting (10) in a study of heat penetration in glass jars determined that heat penetration curves show a lag of 8° F, in a tin can and 20° in a glass jar below that of the surrounding bath. As a cover on the bath may make a difference of 30° much spoilage in home canning may be attributed

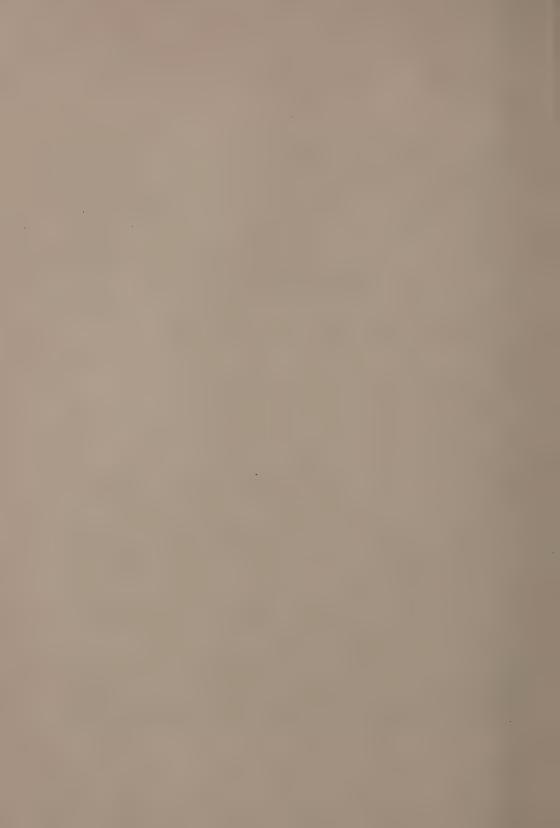
to the use of an open bath.

Since this study was started Shank (25) and her associates have made an investigation of heat penetration in glass jars in oven canning and Gray (18) reported on heat transmission in glass packed products as compared to tin. Gray determined that when the ratio of the rate of heat through the container to the rate of heat through the product is greater than unity it does not matter whether glass or tin is used. When this ratio is less than unity the rate of heat penetration is somewhat faster in tin. When water was used the maximum temperature was reached 3 minutes

Water Bath Set-Up Showing Boiler, Jars with Thermo-Couples, Switch and Potentiometer in Position During Cooling.

FIGURE 1





sooner in tin than in glass, while with sweet corn no difference in time was noted.

In the present investigation the heat penetration in glass pint and quart jars containing various vegetables and meats packed under different home conditions and processed in the boiling water bath and the pressure cooker was studied.

MATERIAL AND METHODS

The equipment* consisted of a specially constructed ten point potentiometer with a switch and thermocouples which were devised for immersion in the water bath. The thermocouples were of copper and constantan wire soldered into Mason jar caps so that the point reached the center of the jar. Copper and constantan wires led from the caps to the potentiometer by means of which the temperature was read. In order to get the wires through the pressure cooker and still have the cooker steam tight, a stuffing box was put through the side of the cooker with metal and rubber discs, which, when forced together, made the connection steam tight. The cover was removed from the pressure cooker and the jars were left in the cooker during the cooling period. The wires used in the hot water bath and leading from the jars to the potentiometer were long enough to allow the jars to be set out of the bath for cooling without removing the caps.

The thermocouples were fastened to both pint and quart Mason jar

caps. Glass pint and quart jars were used.

In both water bath and pressure cooker, the heating period was continued until the temperature at the center of the jar became constant, as evidenced by a cessation of rise of temperature for three consecutive readings at five minute intervals.

The readings of temperatures in the water bath were taken at five minute intervals and those in the pressure cooker at two and one-half minute intervals during the period in which the rate of rise of temperature was

most rapid.

By the term processing temperature which is used in this paper is meant the temperature at the center of the jar which was considered as processing temperature when it approached within two degrees Fahrenheit of the temperature of the boiling water bath. It was considered that this two degree margin in temperature was within the limits of experimental error. It is understood that processing starts at lower temperatures, but for convenience of comparison the processing temperature was thus arbitrarily defined.

Records of rise in temperature are to be found in the thesis (23),

which is on file in the library at Iowa State College.

RESULTS BEEF AND PORK

There are many ideas prevalent at the present time regarding the technique of canning meat. Some people advocate putting a piece of bone into each jar, others claim that there is an advantage in adding fat with the meat, and still others claim that meat keeps better when it is precooked before being put into the jar.

^{*}Designed by Leeds & Northrup, Philadelphia, Pa.

In order to determine the rate of heat penetration into meat, such variations in the pack as mentioned were used. Beef and pork were selected as examples of a lean and fat meat. It was thought that the results obtained with these meats would be applicable to the canning of other meats.

Beef round cut into convenient sized pieces was packed into the jar as cut; with water added, with fat added, with the addition of bone, and after precooking.

The initial temperature of the content of the jars varied with the differences in the preliminary treatment of the beef. The results obtained in the individual experiments with beef are depicted in Figure 2, which compares the rate of heat penetration in the different packs.

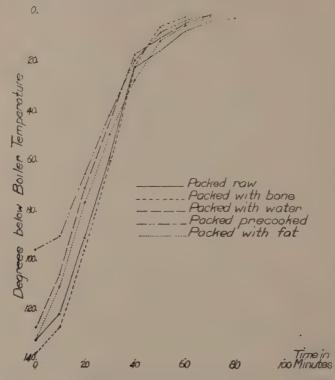


Figure 2. Heat penetration in beef packs in hot water bath.

From this record it will be seen that the beef with the bone heated most quickly to a constant temperature, due, probably, to the fact that the bone in the center of the jar allowed for greater convection currents. The precooked beef heated at a slower rate, due, probably, to the hardening of the fibers during precooking, which made the heat penetrate into the pieces of beef more slowly during the processing. Because of a higher initial temperature, the processing point was reached sooner with the precooked beef than with the beef packed raw. The beef with added fat heated a little

more slowly than the plain beef or than that with added water. The plain beef heated more slowly than the beef with added water, which corroborates the statement of Magoon and Culpepper (21) that in foods in which a free liquid fills the interspaces, the rate of change in temperature is more rapid due to the freedom with which convection currents are formed when it is heated.

Special pack beef round and beef suet—In order to test the heat conductivity of the fat of beef versus that of the lean of beef, two jars were packed solidly with beef suet, and two with a large piece of beef round in the center of the jar and smaller pieces packed around the sides of the jar to make the pack as solid as possible. They were then processed in the hot water bath.

The rate of heat penetration was more rapid into the jar of beef than into the jar of suct until the melting point of the suct was reached. After that point the temperature in the jar of suct rose almost as quickly as if

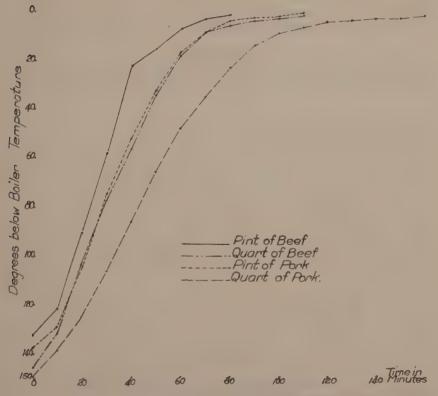


Figure 3. Comparison of heat penetration curves for quart and pint packs of beet and pork in hot water bath.

the jar had been filled with water. With the suet solid, the heating was entirely by conduction, but when the suet became liquefied the heating was

largely by convection. Thus beef fat seems to retard heat penetration as long as it is in a solid condition, but allows for more rapid heat penetration when it is melted.

Pork. The variables used in the packs of pork were: pork loin with and without water, pork sausage plain and with added fat, and pork sausage made into cakes and precooked.

When the heat penetration for the beef and pork packs was compared, it was noted that the jars of pork heated more slowly as a rule than the beef. The heat penetration with the various packs of pork was so nearly the same that the differences in time noted were not significant. The line shown for pork in figure 3 is representative of the rate at which the pork heated in the various packs.

Pint versus quart packs of beef and pork. Comparing the time interval for reaching processing temperature in pint versus quart packs of beef and pork in the boiling water bath it was observed that the quart packs of beef required approximately thirty minutes longer and the quart packs of pork fifty minutes longer than the pints of either to reach processing temperature. These time relationships are shown graphically in figure 3.

VEGETABLES

The vegetables used in this series of heat penetration studies were chosen because each is typical of a class of vegetables, and the result should

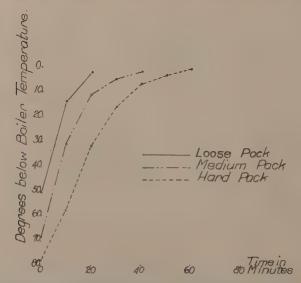


Figure 4. Effect of pack on rate of heating of green beans in hot water bath.

apply to all other vegetables in the same class. Green beans, asparagus, spinach, tomatoes, and sweet corn were used in the experiments and the results of each will be discussed under the individual headings.

Green beans—Three different packs were used for the green beans: 212, 340, and 425 grams of beans per pint. The more compact the pack of beans, the longer the time required for the inner temperature of the jar to

reach the temperature of the water bath or pressure cooker.

The loose pack in the pint glass jar reached processing temperature in twenty minutes time, the medium pack reached it in forty minutes time, and the hard pack required sixty minutes. (See Figure 4.) This difference in time required to reach processing should be taken into account when formulating tables for processing green beans. It is probable that a good time table should specify the most desirable weights of beans to be included in the different sized jars as well as the length of processing time for each.

The tightness of the hard pack in these experiments with beans was such that the appearance of the beans was somewhat impaired. In order to conserve the appearance of the vegetable a slightly looser pack would be more desirable. A consideration other than the appearance of the finished product is the added time required for the contents of a tightly packed jar to reach retort temperature—forty minutes more being required in this experiment for the beans in the hard pack than for those in the loose pack. This may partially account for many of the failures in the home canning of beans.

The results of the experiments with beans in the pressure cooker are similar to those given above for the water bath. The differences in time required for the different packs to approach retort temperature in the pressure cooker were 20, 30, and 60 minutes, respectively, after the closing of the petcock.

Spinach—The variations in the packs of spinach used were 204, 375. and 475 grams of spinach per pint. These packs were practically the same as those used by Castle (12). With spinach as with beans the looser the pack, the more quickly the spinach reached the processing temperature.

The loose pack of spinach as used in these experiments was not practical due to the very large amount of water, one and one-half cups per pint. which had to be added to fill the jars. The medium pack, 375 grams per pint, would ordinarily be considered a loose pack. During the processing period, the spinach tended to pack together and draw away from the sides of the jar, leaving free liquid near the outside of the jar.

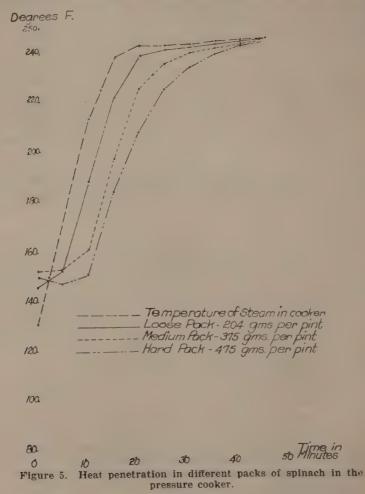
Figure 5 shows the heat penetration in the loose, medium, and hard packs of spinach with the temperature of the retort during processing in

the pressure cooker.

Asparagus—Only two different packs of asparagus were used, 260 and 320 grams of asparagus per pint. The packs would be considered as loose and medium. The effect of using the tips of asparagus cut in one inch pieces was tried. The differences in time for reaching bath or pressure cooker temperature for the two different packs were so slight as to be practically of no consequence.

An additional experiment which indicated the effect of initial temperature on rate of rise of temperature was tried. The conditions in this test were not the same as those in the others in that the water bath temperature was not recorded, nor were the jars heated until constant in temperature but only until all three jars showed the same temperature at the center. Asparagus in all three cases was cut into one inch pieces and 300 grams

used per pint. The contents of the first jar were precooked, of the second scalded, and of the third packed into the jar cold and covered with boiling water. The initial temperatures in the three jars were 185° F., 182° F., and 133° F., respectively. At the end of 20 minutes heating in the water bath, all three jars had reached a temperature of 205° F. This is in accordance with the results of Magoon and Culpepper (22), who show that two jars with different initial temperatures in the same retort reach retort temperature at practically the same time. Thus the jar with the lower



initial temperature heats at a faster rate than the one with the higher initial temperature.

This would also apply to vegetables such as beans and peas, which are like asparagus, in that the pack allows free liquid to fill the interspaces and thus convection currents are quickly set up.

Tomatoes—The tomatoes were processed as tomato pulp and puree. The pack used was 500 grams of tomato per pint and 950 grams per quart. A final temperature as high as that of the water bath or pressure cooker is not necessary in canning tomatoes. The sterilizing temperature for tomatoes need not be as high as for other vegetables, because of their natural acidity. Consequently a much shorter processing time is required than for other vegetables. The tomatoes were processed in the water bath for 5, 12, 20, 25, 35, 45 minutes and in one instance until constant in temperature, i.e. 70 minutes. In the pressure cooker they were processed at 5 lbs. pressure for 20 minutes, 10 lbs. pressure for 10 and 15 minutes and at 15 lbs. pressure for 10 minutes.

When the tomatoes were removed from the water bath or the gas turned off under the pressure cooker, the temperature in the center of the jars continued to rise. Since the temperature at the center of the jar was not as high as that near the outside, the heat radiated both into and out of the jar. The lower the temperature at the center of the jar at the end of the processing period the longer the interior tmperature continued to rise, with the exception of the five minute process in which the temperature

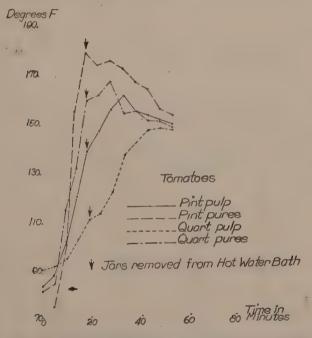


Figure 6. Heat penetration in tomato pulp and puree, pints and quarts, in the hot water bath.

continued to rise for five minutes less time than in the 12 minute process. This was probably due to the fact that the temperature of the tomato near the outside of the jar rose only a few degrees in the short processing period. The interior temperature of the tomatoes heated to a constant temperature

TABLE I. HEAT PENETRATION IN PINT JARS OF TOMATO PULP.

	Process time in minutes						
	5	12	20	25	35	45	
Elapse of time				Tempe	rature		
Minutes	°F.	°F	°F	°F	°F	°F	
0	84.6	70.0 72.3	84.0	74.2	76.2	88.5	
3 5	88.8*	74.6	88.6	78.6	79.3	93.1	
10 12	89.6	85.6 89.2*	101.4	84.5	82.4	104.0	
15 20	104.6 114.7	92.8 114.8	120.0 138.5*	$105.5 \\ 124.1$	104.4 126.4	123.2 141.0	
25	117.8	126.8	146.6	143.5*	141.8	158.1	
30 35	119.6 118.5	128.9 131.8	155.5 1 6 0.5	150.0 161.6	157.2 173.0*	170.8 182.6	
40 45	116.2	135.0	154.5 152.7	162.2 162.7	173.8 181.0	190.4 194.8	
50 55	And the second s	0	150.5 148.1	160.0 156.6	183.6 168.3	189.1 190.0	
60 65		e Barbana di cana		152.5	154.2 141.6	175.2 160.3	
70 75	** Williams**	- management			137.6	147.5 140.1	

^{*}Jars removed from boiler and placed on the table.

TABLE II. HEAT PENETRATION IN QUART JARS OF TOMATO PULP.

		Proces	ss time in mi	nutes	
Elapse of time	12	20	25	35	45
			Temperature		
Minutes	°F	°F	°F	°F'	°F
0	86	90.5	73.0	84.7	81.1
3 5	88.5				
	85.8	91.6	74.4	84.7	81.7
10	85.7	94.8	75.7	87.5	84.7
12	87.9*				
15	90.6	102.4	82.4	97.8	93.3
20	102.8	110.4*	90.1	107.4	104.0
25	110.9	113.0	112.2*	119.3	115.0
30	116.0	121.8	111.4	132.0	127.1
35	120.5	135.6	128.2	143.1*	139.8
40	123.2	141.3	137.2	146.8	147.8
45	124.4	146.9	142.4	155.2	156.8*
50	1	147.2	145.4	161.6	156.2
55		146.3	145.2	167.7	167.0
60 .	4		145.0	163.4	167.9
65				160.7	162.7
70				157.2	159.7
75	İ				153.7

^{*}Jars removed from boiler and placed on table.

did not continue to rise after being removed from the water bath, due to the fact that the temperature at the center of the jar was as high as that near the outside on removal.

The tomato puree, which was of uniform consistency, heated more quickly than the tomato pulp. This was true for both pints and quarts, with the quart of tomato puree heating faster than the pint of tomato pulp. This is illustrated in figure 6.

The tomatoes on removal from the bath in the 20 and 25 minute process were at a temperature of approximately 140° F. when removed. Because of the continued rise in temperature following removal from the bath it will be noted that the tomatoes were at a temperature above 140° F. for

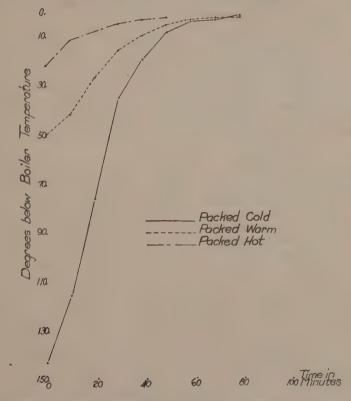


Figure 7. Heat penetration in sweet corn packed at different initial temperatures.

a period of 35 minutes. A part of the data for the boiling water bath processed tomatoes is given in tables I and II.

Sweet corn. The sweet corn used in these experiments was mature Stowell's Evergreen. It was cut from the cob "Maine style", the tips being cut away with a sharp knife and the milk scraped from the cob.

Three different packs were used for the sweet corn, 274, 320 and 384 grams per pint. The water added was 206, 160, and 96 grams, respectively. When pint jars containing these varying amounts of corn were heated in the boiling water bath the loose pack reached processing temperature in 50 minutes, and the medium and solid packs in 90 minutes. Quart jars with a loose pack reached processing temperature 60 minutes sooner than the quarts with a medium or solid pack. In the pressure cooker, pint and quart jars of corn approached retort temperature 20 minutes sooner in the loose pack than in the medium and solid packs. From the standpoint of heat penetration the more water that is added to the corn the sooner the desired temperature is reached.

In the hot water bath, quart jars of sweet corn reached processing temperature 40 to 60 minutes later than pint jars under the same condi-

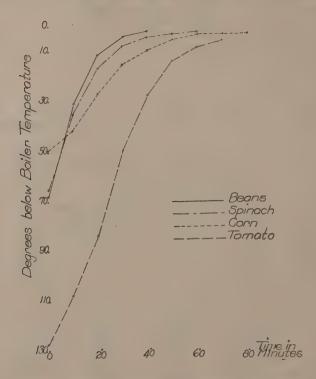


Figure 8. Heat penetration as influenced by consistency of vegetables.

tions. In the pressure cooker, the difference between the pints and quarts was about 20 minutes.

The initial temperature of the sweet corn at time of packing was important in determining the length of time required for the corn to reach processing temperature. Figure 7 shows comparative curves for medium packs of sweet corn packed at different initial temperatures. It will be noted that the corn packed hot reached processing temperature 30 min-

ntes sooner than that packed warm or cold. This advantage in time was not observed in jars processed under pressure, as in this case the jars with different packs reached 212° F. at practically the same time. However, according to Harrison (19) a 2° F. increase in the initial temperature in the range of 180° to 200° F. may be considered as equivalent to adding one minute to the processing time. (Processed at 245°F.) He stated that 20 minutes should be added to the processing period if the center of the can is 122° instead of 182° F. (Processed at 252° F.)

Heat penetration in corn is slow because of the pasty or viscous consistency, thus any factors which decrease the time required for the center of the jar to reach maximum temperature should be observed. The use of a loose pack and a high initial temperature in the home canning of corn should have a favorable influence on the keeping qualities.

Consistency of the vegetable. To illustrate the influence which the composition of the material has upon the rate of heat penetration, curves depicting the heat penetration in medium pint packs of beans, spinach, corn and tomato are compared in figure 8. A vegetable of the consistency of corn would be expected to take a longer time to reach processing temperature because of its more viscous composition. The corn took 40 minutes longer than the beans. The time for the spinach was intermediary between that for corn and beans. The rate of penetration in tomato pulp is similar to that of corn. The tomatoes started at a lower temperature and were removed before the contents of the can reached the temperature of the water bath.

Pint versus quart packs of vegetables. Medium packs of corn, beans, asparagus, spinach and tomatoes in pint and in quart jars were compared for length of time required to reach the processing temperature in the boiling water bath. It took one hour longer to heat the medium quart pack of corn to processing temperature than it took for the medium pint pack of corn. In the case of the beans, asparagus and spinach, it took 10-20 minutes longer for the quarts of medium pack than for the pints of medium pack. The tomatoes in quart jars took approximately 10 minutes longer to reach an effective processing temperature in the centers of the jars.

Special pressure cooker tests—In order to determine the best method for the use of the petcock for maximum efficiency in the operation of the pressure cooker*, a series of tests were made leaving the petcock open for varying lengths of time. Green beans in the different packs were used in the first series of tests.

The pressure recorded on the gauge of the pressure cooker is used as an index of the temperature inside the cooker. With air left inside the cooker, however, a pressure may be obtained which causes the gauge to indicate a certain temperature when in reality the temperature is not as high as the pressure indicates.

Ball (3) states that the uniformity of temperature within the retort depends largely upon whether or not there is air in the retort and that in pure steam processing, venting should be sufficient to remove the air quickly after the steam is turned on.

The Anchor Cap and Closure Corporation (1) report with regard to retort control that in using a retort which has the vents closed throughout

^{*}A National Pressure Cooker No. 25 was used.

7 min. after steam

the entire process, thus necessitating higher pressures to secure the desired temperature, the pressure developed inside the sealed retort will equalize the pressure developed inside the glass containers.

Harrison (19) secured a temperature of 250° F, in four minutes with both the safety valve and the bleeder valves of a commercial retort open, but it took 15 minutes to secure the same temperature with only the bleeder valves open.

The following technique was used for the pressure cooker experiments. The petcock was either kept closed throughout, or closed with the appearance of steam or left open for varying lengths of time after the appearance of steam, 2, 3, 5, and 7 minute intervals being tried.

The theoretical temperatures on the basis of the pressure gauge readings were compared with the actual temperatures observed by thermocouple determinations. These are recorded in table III.

TABLE III. PRESSURE COOKER AND AUTOCLAVE OPERATION TESTS.

Pet Cock Closed	Observed Pressure Gauge Readings (Average)	Temp. on basis of Gauge Readings	Observed Temp. of Steam in Retort (Average)	Difference be- tween temps. indicated by pressure gauge and ob- served read- ing
	lbs.	°F	°F	°F
Throughout	12	243	193.5	49.5
At appear. of steam	13.6	246	231.2	14.1
3 min. after steam	13.2	246	238	8

Test 1-Pressure Cooker

armin a	A 70	~ 1
Test	2-Pressure	Cooker

15

249

244

	lbs.	°F'	°F	°F
Throughout	15	249	210	39
At appear, of steam	15	249	232	17
3 min. after steam	15	249	241	8
5 min. after steam	15	249	245	4
7 min. after steam	15	249	245	4

Test 3-Autoclave

	lbs.	°F	°F	°F
Throughout	15	249	197.6	51.4
At appear, of steam	15	249	203.0	46.0
2 min. after steam	15	249	222.8	26.1
5 min. after steam	15	249	242.6	6.4
7 min. after steam	15	249	244.4	4.6

It will be observed that when the petcock was not closed until steam had escaped for 7 to 10 minutes after the first appearance of steam, that with the gauge reading of 15 lbs. the difference between the observed and theoretical temperatures of the steam was 5° F. The differences observed in the other tests increase as the time for allowing enclosed air to escape

is shortened. The maximum difference between theoretical and observed readings was obtained with the petcock kept closed throughout the test.

A second test was conducted with the pressure cooker keeping the gauge readings uniformly at 15 lbs. pressure throughout and with water in the pint jars instead of beans. The differences between retort and theoretical readings are similar to those obtained in the first tests. See table III and figure 9 for presentation of results obtained in second test.

A third test was conducted using an autoclave* (30 by 20 inches) instead of the pressure cooker. The steam was generated by a high pressure steam coil. The differences in temperatures between autoclave temperature and theoretical temperatures based on pressure gauge readings are even more pronounced in this series. See table III.

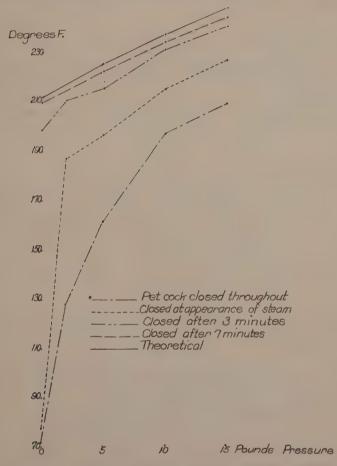


Figure 9. Variation in interior temperature of pressure cooker due to petcock technique used.

^{*}No. 1686. Horizontal Autoclave. Arthur H. Thomas Co., Philadelphia.

From the tests described, it is evident that marked differences in retort temperature can be obtained, depending on the technique of operating the pressure cooker. The differences in temperature are great enough to account for spoilage in products canned in the pressure cooker if inefficient technique is used. Bigelow (8) emphasizes the importance of accurate temperature, noting that in processing peas if 239° F. instead of 240° F. was used an additional six minutes should be added to the processing period.

SUMMARY

Experiments on the heat penetration into pint and quart glass jars of vegetables and meats processed in the hot water bath and pressure cooker are reported.

The heat penetration was determined by means of thermocouples and a potentiometer.

The foods processed were beef round, beef suet, pork loin, pork sausage, green beans, spinach, asparagus, sweet corn and tomatoes.

Size of the jar, variations in pack, initial temperature, and consistency of the products were considered for their influence on the time of heat penetration.

An efficient method of pressure cooker operation was determined, and the possibility of inefficient operation during processing pointed out.

CONCLUSIONS

- 1. The variables ordinarily used in packing canned meat, such as the addition of water, bone and fat, have but slight influence on the heat penetration during processing in glass. This is true both for the boiling water bath and the pressure cooker. Precooking the meats makes the heat penetrate more slowly, but because of the higher initial temperature the time required for reaching processing temperature is slightly less than that for raw meat.
- 2. Beef fat retards heat penetration in meat as long as it is solid, whereas when it is liquefied the heat penetration is very rapid.
- 3. The variables used in canning vegetables, as size of jar, closeness of pack, initial temperature and consistency of the vegetable, have a decided influence on the time required for penetration of the heat to the interior of the jar.
- 4. Closeness or tightness of pack delays heat penetration by influencing the rate at which the heat penetrates the product—the looser pack heating more rapidly. The medium packs used in these experiments were more desirable than either the loose or hard packs from the standpoint of convenience in packing and appearance of the product.
- 5. Because of the longer time it takes for the heat to penetrate to the center of the quart jars, additional processing time should be allowed when using time tables specified for pints. Additional time lengths suggested are; for beans, asparagus and spinach 10-20 minutes, for tomatoes 10 minutes, for sweet corn 60 minutes, for beef 30 minutes, and for pork 50 minutes.

- 6. Unless precautions are taken to allow the exhaustion of the air in the pressure cooker before closing the petcock, a lower temperature is obtained than that indicated by the pressure gauge.
- 7. Leaving the petcock of the pressure cooker open for seven minutes after the appearance of steam gave the maximum temperature under the conditions of the experiments.

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CATALASE AND OXIDASE OF THE TOMATO AS INFLUENCED BY THE SOIL REACTION*

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One of the important alterations occurring in bench soils in greenhouses is the change from a slightly acid reaction, common to most soils when first placed in the benches, to a highly alkaline reaction, due to the addition of alkaline material in watering.

The present problem was undertaken to determine the effect of the soil reaction (pH value), first, on the growth of the tomato plant, and,

second, its effect on catalase and oxidase activity.

No attempt will be made to give a complete review of the literature pertaining to catalase and oxidase activity. Only those references will be cited which have a direct relation to the data given here, since Ezell and Crist (7), Heinicke (10), Knott (13), Rhine (16) and others have covered the subject thoroughly.

Ezell and Crist (7), working with lettuce, radish and spinach plants, found only a slight negative correlation between oxidase activity and growth or size of the plants, but the catalase activity of the same plants was negatively significant. Reed (15) demonstrated that oxidase and catalase were independent of each other and that in the ripening of fruit

catalase increased while oxidase remained constant or nearly so.

Catalase activity in relation to growth in fruit trees, especially the apple, has been studied considerably by Heinicke and his co-workers. Heinicke (10) found growth-producing substances increased catalase activity while substances which tended to inhibit vegetative activity had a retarding influence on catalase activity. Organic nitrogenous materials seemed to increase the activity while carbohydrates were believed to be the chief cause of reduction in catalase activity. The same author (11) found apple trees grown on sandy soil showed less catalase activity in the leaves than those from trees growing on a clay soil, whether the trees were cultivated or grown on sod. Apple trees when grown in sod and given applications of nitrate of soda up to 8 ounces per tree showed an increase in catalase activity of the leaves. Heinicke (12) also determined that fruiting tends to reduce catalase activity in the bark of the apple tree. By applying nitrates to only one side of the trees Auchter (3) obtained increased catalase activity on the nitrated side. Biechy (5) found that an addition of potassium fertilizer decreased the catalase activity of the plant. According to Knott (13) the catalase activity of spinach leaves was not influenced either by vegetative or reproductive type of growth.

^{*}Part II of a thesis submitted to the Graduate Faculty of the Iowa State College in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Grüss (8) reported that it was impossible to make quantitative determinations of catalase in fresh potato extract on account of the rapid degeneration during and after grinding. Appleman (2), however, discovered that if the potato was ground with calcium carbonate to neutralize the acids freed by the grinding, diluted immediately and kept at 20° °C. or below, this rapid degeneration was overcome and comparable results could be secured without any difficulty. Heinicke (10) found that the amount of calcium carbonate equal to the green weight of the tissue was in excess of that needed for the acidity to be corrected, but far more could be added without affecting the reaction. Becking and Hampton (4) using sodium carbonate to neutralize the plant acids concurred in this belief. According to Knott (14) catalase activity of the tomato and spinach decreased more slowly at cool temperatures.

According to Ezell and Crist (7) samples of tissue prepared for the determination of oxidase activity should be allowed to stand for about six hours before using. Oxidase activity of the sample increased for about six hours and then remained constant for ten or twelve hours, after which

there was a slow decline.

MATERIALS AND METHODS

New compost soil was placed in the greenhouse bench. The individual plots were separated by boards that extended the entire depth of the bench in order to prevent the soil of one plot from mixing with that of another. The reaction (pH value) of the soil when placed in the benches was 6.5.

Since the soil was always acid when placed in the bench and became highly alkaline due to the addative effect of salts in watering, three reactions (pH values) were decided upon, one extremely alkaline, pH8.5-9.0, one neutral or nearly so, pH 6.5-7.0, and one extremely acid, pH 4.0-4.5. These plots were all run in duplicate. To secure the alkaline reaction, the soil was treated with hydrated lime in sufficient quantity so that the pH value was about 9.0 a week after treatment, when a fair degree of equilibrium was reached. For the neutral plots the soil was not treated, since it was nearly neutral without treatment. The acid reaction was secured by adding phosphoric acid (H_3PO_4) so that the reaction was 4.0 a week after treatment.

The tomato plants used were of the Bonny Best variety. The seed was sown in a flat, the seedlings pricked off when one and one-half inches high and planted in two-inch pots, later shifted to four-inch pots and finally transferred to the treated plots ten days after the soil had been treated. The soil used in potting was ordinary compost with a pH value of 6.0-6.5.

The fall crop was placed in the greenhouse bench October 1 and completed its growth February 1. The spring crop was placed in the bench February 20. Determinations of the pH values of the soil of the various plots were made at ten-day intervals after the crop was benched. Small amounts of hydrated lime or phosphoric acid were added from time to time to keep the pH within the desired range.

To secure the desired information regarding growth and fruit production, yields were recorded by weighing the fruits when ripe. Relative growth on the various plots was secured after the fruit had been harvested. The plants were dug, the roots washed free of soil with tap water and then washed with distilled water. Roots, stems and leaves were separated

from each plant and air-dried in the laboratory for four weeks with the temperature ranging from 75° to 85° C., and then weighed to determine the relative amount of growth. Catalase and oxidase activity were measured on fresh material of leaves and fruit on both spring and fall crop.

For measurement of catalase activity essentially the same method was employed for preparation of samples as that used by Ezell and Crist (7). A composite sample from several plants was made by means of a Ganong leaf punch. The leaves from which samples were taken were just reaching vegetative maturity and samples were taken from the same aged material each time to secure comparable results, since young tissue had been found by numerous investigators to be more active with regard to most enzymes than old tissue. One gram of leaf tissue weighed immediately after removal from the plant was used for all leaf determinations. Samples of the fruits were taken by punching out a cylinder by means of a cork borer one centimeter in diameter. Fruits of approximately the same size and degree of maturity were used and the sample weighed immediately. The sample of both leaf and fruit was mixed with an equal weight of dry calcium carbonate, then 2 c.c. of distilled water added and the mixture ground gently in a mortar until a uniform creamy mixture was obtained. Distilled water was then added so that the fresh ground tissue was suspended in 25 c.c. of water. The solution was then placed in a tightly stoppered bottle and kept on ice until used.

Catalase activity was determined by Harvey's (9) modification of the Bunzel oxidase apparatus. Two c.c. of the plant solution were placed in the short arm of the tube and 5 c.c. of hydrogen peroxide in the long arm of the tube. The tube was suspended in a DeKhotinsky water bath held constant at 35° C. Uniform shaking was accomplished by means of a motor-driven mechanical shaker. The oscillations were timed so as to cause the solution to flow from one end of the tube to the other at the rate of 90 times per minute. Before shaking commenced the tube containing the materials was placed in the bath and allowed to stand for ten minutes until it had reached the temperature of the bath. The tube was then shaken for three minutes and the amount of oxygen evolved measured.

For the measurements of oxidase activity, portions of samples prepared for catalase determinations were used for oxidase determinations. The procedure was essentially the same as that used by Ezell and Crist (7). Two c.c. of the prepared sample were placed in the short arm of the tube, while 5 c.c. of a fresh one percent pyrogallol solution were placed in the long arm of the tube. An alkali vial containing 1 c.c. of normal sodium hydroxide was put in place and the manometer adjusted. The reaction tube was placed in the bath 10 minutes before shaking to allow the materials to reach the temperature of the bath. The reading of the manometer at the end of 1 hour was taken as a measure of oxidase activity.

Checks were run on all samples for both catalase and oxidase. All results given are from samples which checked within 0.2 c.c. Samples from the same plot taken the same day checked within this range. All results given are averages from four samples.

EXPERIMENTAL WORK

EFFECT OF SOIL REACTION ON GROWTH AND YIELD

As will be noted in table I the soil reaction had considerable effect on both yield and growth of the tomato.

TABLE I. EFFECT OF SOIL REACTION ON GROWTH AND YIELD OF TOMATO PLANTS.

Soil	Yield per		age weight per faterial air-drie		
Reaction	plant	Roots	Stems	Leaves	Total
pH 8.5-9.0 pH 6.5-7.0 pH 4.0-4.5	2.52 lbs. 4.06 lbs. 3.04 lbs.	2.52 gms. 2.30 gms. 2.34 gms.	32.90 gms. 31.25 gms. 24.74 gms.	56.90 gms. 79.80 gms. 57.84 gms.	92.32 113.35 84.92

Two plants on one of the acid plots and three plants on the alkaline plots showed evidence of mosaic, and were discarded. One of the vines on an acid plot in the series became infected with wilt and was likewise discarded.

The largest yield per plant was secured on plots where the soil reaction had a pH value of 6.5-7.0 and the smallest yield on the alkaline plots, pH 8.5-9.0. Maximum root growth as measured by the weight of the airdried material occurred on the alkaline plots. There was very little difference in root growth between plants grown on the neutral or acid plots. The greatest amount of total dry matter was secured on the plots with a neutral soil reaction, while the alkaline plots produced only 81.4 percent as much total dry matter as the neutral plots, and the acid plot only 74.9 percent as much.

EFFECT ON CATALASE AND OXIDASE ACTIVITY

Measurement of catalase and oxidase activity were made on the leaves and fruit of both fall and spring crop. Tables II to V, inclusive, give the results of the findings with respect to oxidase and catalase activity for the fall crop.

Differences in catalase activity were most pronounced in the case of the green mature fruits. Fruits on plants from soils with a reaction of pH 6.5-7.0 consistently showed less catalase activity than those from soils with pH 8.5-9.0 and 4.0-4.5.

Fully ripe fruits from the neutral plots also showed less activity than those from the acid or alkaline plots, but the differences were not so marked as in the green mature fruit. No consistent differences in catalase activity were noted in the very green fruits, but catalase activity was at the minimum at this stage of maturity, so if there were any differences, they were not significant.

TABLE II. CATALASE AND OXIDASE ACTIVITY OF TOMATO FRUITS OF DIFFERENT STAGES OF MATURITY GROWN IN SOILS WITH DIFFERENT PH VALUES.

December 20

Soil	Oxidase c.c. of Hg displaced	Catalase (c.c. of water displaced)			
Reaction	at end of 60	Time in minutes			
	minutes	1	2	3	
	Green	Mature Fruit			
pH 8.5-9.0	1.70	1.1	1.3	1.5	
pH 6.5-7.0	1.50	0.8	0.9	0.9	
pH 4.0-4.5	1.80	2.7	3.3	3.7	
	R	tipe Fruit			
pH 8.5-9.0	1.65	0.9	1.1	1.3	
pH 6.5-7.0	1.75	1.3	1.5	1.7	
pH 4.0-4.5	1.35	1.4	1.7	1.9	
	Gı	reen Fruit			
pH 8.5-9.0	1.10	0.6	0.7	0.7	
H 6.5-7.0	1.25	0.7	0.9	1.0	
H 4.0-4.5	1.30	0.7	0.8	0.9	

TABLE III. CATALASE AND OXIDASE ACTIVITY OF TOMATO FRUITS OF DIFFERENT STAGES OF MATURITY GROWN IN SOILS WITH DIFFERENT pH VALUES.

January 5

Soil	Oxidase c.c. of Hg displaced	(c.c	Catalase of water displ	aced)	
Reaction	at end of 60	T ime in minutes			
	minutes	1	2	3	
	Green	Mature Fruit			
pH 8.5-9.0	1.40	1.6	1.8	2.0	
pH 6.5-7.0	1.55	1.0	1.2	1.3	
pH 4.0-4.5	1.70	2.7	3.0	3.3	
	Ri	pe Fruit			
pH 8.5-9.0	2.00	2.3	2.7	2.9	
pH 6.5-7.0	1.95	0.8	1.0	1.1	
pH 4.0-4.5	2.10	0.9	1.1	1.2	
	Very	Green Fruit			
pH 8.5-9.0	.95	0.5	0.7	0.8	
pH 6.5-7.0	1.05	0.5	0.6	0.6	
pH 4.0-4.5	1.25	0.7	0.9	1.0	

TABLE IV. CATALASE AND OXIDASE ATCIVITY OF TOMATO FRUITS OF DIFFERENT STAGES OF MATURITY GROWN IN SOILS WITH DIFFERENT DH VALUES

January 19

Soil	Oxidase c.c. of Hg displaced					
Reaction	at end of 60	Time in minutes				
	minutes	1	2	3		
	Green	Mature Fruit				
pH 8.5-9.0	1.80	2.2	2.4	2.6		
pH 6.5-7.0	1.75	1.0	1.2	1.3		
pH 4.0-4.5	1.90	2.4	2.7	. 2.9		
	R	ipe Fruit				
pH 8.5-9.0	2.10	0.9	1.0	1.1		
pH 6.5-7.0	2.18	0.9	1.0	1.1		
pH 4.0-4.5	1.90	1.0	1.3	1.4		
	Gr	een Fruit				
pH 8.5-9.0	1.00	0.7	0.9	1.0		
pH 6.5-9.0	.90	0.7	0.8	0.9		
pH 4.0-4.5	.90	0.6	0.7	0.7		

TABLE V. CATALASE AND OXIDASE ACTIVITY OF TOMATO FRUITS OF DIFFERENT STAGES OF MATURITY GROWN IN SOILS WITH DIFFERENT ph values.

February 1

Soil	Oxidase c.c. of Hg displaced	(c.c.	Catalase of water displa	aced)	
Reaction	at end of 60	Time in minutes			
	minutes	1	2	3	
	Green	Mature Fruit			
pH 8.5-9.0	1.90	2.0	2.2	2.4	
pH 6.5-7.0	1.90	1.2	1.3	1.3	
pH 4.0-4.5	1.80	2.4	2.7	2.9	
	Ri	pe Fruit			
pH 8.5-9.0	1.75	1.0	1.3	1.5	
pH 6.5-7.0	1.90	1.3	1.5	1.6	
pH 4.0-4.5	2.00	1.4	1.7	1.9	
	Gr	een Fruit			
pH 8.5-9.0	1.10	0.6	0.7	0.7	
pH 6.5-7.0	1.15	0.7	0.8	0.9	
pH 4.0-4.5	1.25	0.7	0.9	1.0	

Oxidase activity was greater in ripe than in the very green or green mature stages, but this was independent of the soil reaction or growth and yield. The oxidase activity of ripe fruits from acid, alkaline or neutral plots was practically the same.

Since the least catalase activity occurred in fruits taken from plots of pH 6.5-7.0, it was thought that this difference in activity might be due to differences in pH value of the fruit in various stages of ripening. The juice of the fruits was squeezed out through several layers of cheese cloth and the pH value of the juice determined by the quinhydrone method. The following table shows the results.

TABLE VI. THE pH VALUE OF THE TOMATO FRUIT IN DIFFERENT STAGES OF RIPENING.

Soil	Condition	pН	pH
Reaction	of fruit	January 13	January 20
pH 8.5-9.0	Ripe	4.25	4.11
	Mature Green	4.03	3.91
	Green	4.11	3.98
pH 6.5-7.0	Ripe	4.25	4.11
	Mature Green	3.75	3.94
	Green	3.96	4.08
pH 4.0-4.5	Ripe	4.29	4.13
	Mature Green	4.04	3.95
	Green	4.06	4.03

In general, the changes in pH value were not great, but this might be expected in a well-buffered solution such as that of the fruit juice. In ripe, mature green and very green samples taken from the same plot the pH value was slightly lower in the green mature stage than in the very green or ripe stages. However, the differences were not great enough to account for the increase or decrease in catalase activity at any particular stage of development of the fruit or from any particular soil reaction.

Catalase and oxidase activity in the leaves was measured first on December 20 when the fruits were beginning to ripen; again on January 12 when about one-half of the crop had been picked and again on February 1 when practically all of the crop had matured. (Table VII.)

TABLE VII. CATALASE AND OXIDASE ACTIVITY OF TOMATO LEAVES
GROWN IN SOILS WITH DIFFERENT pH VALUES.

December 20

	200	0			
Soil	Oxidase c.c. of Hg displaced	Catalase (c.c. of water displaced)			
Reaction	at end of 60	at end of 60 Time in mir			
	minutes	1	2	3	
pH 8.5-9.0	1.55	4.0	5.2	5.7	
pH 6.5-7.0	1.55	3.3	4.3	4.8	
pH 4.0-4.5	1.40	3.8	5.3	5.9	
	Jai	nuary 12			
pH 8.5-9.0	1.30	5.1	6.5	7.4	
pH 6.5-7.0	1.40	2.8	3.8	4.4	
pH 4.0-4.5	1.25	8.8	8.6	9.7	
	Fel	bruary 1			
pH 8.5-9.0	1.50	4.5	6.8	7.6	
pH 6.5-7.0	1.40	3.3	5.1	5.6	
pH 4.0-4.5	1.45	4.5	6.9	7.8	

The oxidase activity of the leaves was not influenced by the soil reaction or resulting growth. Catalase activity of the leaves showed the same relationship with reference to soil reaction and resulting growth as the green mature fruits, i. e., the least catalase activity occurred in the plants from plots with a soil reaction of pH 6.5-7.0. Measurements made on December 20 showed less catalase activity on all plots than those made on January 12 and February 1.

Since the soil reaction and resulting growth apparently had no effect on the oxidase activity of fruits or leaves for the fall crop no measurements were made on the spring crop. Catalase activity in the leaves was measured at two-week intervals, on March 30, April 12 and April 26. Determinations were made on the fruits on only one date, namely April 27. When leaf samples of March 30 and April 12 were taken only small green fruits were present in the first three clusters. Results are given in table VIII.

TABLE VIII. CATLASE ACTIVITY OF LEAVES AND FRUIT OF THE SPRING CROP OF TOMATOES.

		Soil	Catalase (c.c. of water displaced) Time in minutes			
Date	Sample	Reaction				
	1		1	2	3	
	1	pH 8.5-9.0	3.8	5.1	5.6	
March 20	Leaves	pH 6.5-7.0	3.0	4.1	4.9	
		pH 4.0-4.5	3.9	5.2	5.8	
		pH 8.5-9.0	4.6	5.4	6.1	
April 12	Leaves	pH 6.5-7.0	2.9	3.6	3.8	
-		pH 4.0-4.5	3.1	4.5	5.7	
		pH 8.5-9.0	4.2	5.1	5.9	
April 26	Leaves	pH 6.5-7.0	2.0	2.5	2.9	
		pH 4.04.5	4.1	5.2	5.8	
	Green	pH 8.5-9.0	1.1	1.7	2.1	
April 27	Mature	pH 6.5-7.0	0.8	0.9	1.0	
	Fruit	pH 4.0-4.5	2.8	3.5	3.8	
	and the same of th	pH 8.5-9.0	1.2	1.5	1.8	
	Ripe	pH 6.5-7.0	0.9	1.1	1.3	
April 27	Fruit	pH 4.0-4.5	1.4	1.7	1.9	
		pH 8.5-9.0	0.7	0.8	0.9	
	Green	pH 6.5-7.0	0.7	0.7	0.7	
April 27	Fruit	pH 4.0-4.5	0.7	0.9	1.0	

Results on catalase activity in the spring crop agree with those secured on the fall crop. Catalase activity of the leaves was less on the neutral plots (pH 6.5-7.0) and greater on the acid (pH 4.0-4.5) and alkaline (pH 8.5-9.0) plots. Both ripe, very green and green mature fruits showed the same relation to soil reaction and growth as the leaves, though the difference in the case of the very green fruit may be within the limits of experimental error. As with the fall crop, catalase activity was greater in the leaves than in the fruit.

DISCUSSION

The soils used in the plots were all of the same type, were uniformly prepared by composting and were thoroughly mixed in a highly efficient soil shredder; it was thought that this method would reduce the variable factors to a minimum. The use of soils with natural pH of the desired range was suggested. It was thought that the variations in fertility between the soils from various sources would increase the variable factors which influence growth.

The use of water or sand cultures with pH values of the desired range would no doubt have kept the variable factors to the minimum, but growth of the plants would not have been comparable to that secured when plants were grown in soil. Since this was a study of greenhouse soils, the conditions were more nearly comparable than with water or sand solutions.

By the addition of phosphoric acid to secure the acid reaction and hydrated lime to obtain the alkaline reaction, the calcium, hydrogen, hydroxyl and phosphate ions and the action of these on materials in the soil were factors which might affect the growth and yield of the plant. However, since the respective ions may cause acidity or alkalinity as measured by pH, the acidity or alkalinity of the soil was considered in general

as the factor which caused variation in growth and yield.

Only the acid plot was treated with phosphoric acid, but available phosphorus was present in the soil in sufficient quantities on the neutral and alkaline plots to secure normal growth. Repeated tests and observations of plant growth in the compost used in the greenehouse benches showed that it contained enough of the essential elements for plant growth without the addition of any fertilizers. Hence, phosphorus was readily available on all the plots. The same was true for calcium added in the hydrated lime.

Sixteen plots in the greenhouse with soil reactions ranging from pH 3.5 to 9.0, used for another set of experiments, gave similar results with reference to yield and growth as the six plots included in this experiment. The largest yields and maximum growth were secured on the plots with a soil reaction which was neutral or slightly acid.

Van Alstine (18), Tarr and Noble (17), Duggar (6) and Appel (1) reported chlorotic effects from the use of nutrient solutions where the pH was on the alkaline side. This was said to be due to the insolubility of the iron. No such results occurred on the plants grown in the greenhouse plots

in a soil with a similar reaction.

The data show clearly that there was a relation between the catalase activity and amount of growth and yield in the tomato. The differences in catalase activity of leaf tissue from plants growing in various soil reactions were greater than in the fruit. Catalase activity was much greater in the leaf tissue than in any stage of maturity of the fruit and may account for these greater differences.

The catalase activity in very green fruits was very low and consequently no consistent difference could be noted between fruits from the various plots. Catalase activity of the fruit appeared to be greatest in the green mature stage, and consistent differences due to conditions of growth were noted. As the fruit ripened catalase activity again decreased for fruits from all the plots.

Knott (13) found in spinach that when the plant changed from a vegetative to a reproductive type of growth the catalase activity decreased. In the experiments reported here yield and growth were associated on the neutral plot and catalase activity decreased under these conditions. Since production of fruit was high on the neutral plots, the type of growth secured could not be considered a vegetative type. The results reported here with respect to catalase activity were in accord with the results of Ezell and Crist (7), who found a negative correlation between yield and growth and catalase activity in the leaves of the apple. Heinicke (11) found catalase activity was reduced in the bark of the apple tree by fruiting. He concluded that growth-producing substances increased catalase activity, while substances which retarded vegetative activity had a retarding influence on such activity. Ezell and Crist (7) took exception to this, since their results, especially with lettuce, showed that, as growth increased, catalase activity decreased.

It appears from the present work that increased growth accompanied by increased yield may be associated with decreased catalase activity. Heinicke (11) considered only increased growth as associated with decreased catalase activity and disregarded yield of fruit as a factor.

No correlation was found in the present work between growth, yield and oxidase activity. Reed (15) found catalase and oxidase activity to be independent of each other, and this is substantiated here.

SUMMARY

Tomatoes grown on soil with a pH value of 6.5-7.0 gave higher yields and made greater growth as measured by total dry matter than tomatoes grown on soils of pH values of 4.0-4.5 and 8.5-9.0.

Catalase activity, growth and yield were negatively correlated in the vegetatively mature leaves, green mature fruit and ripe fruit. No apparent differences were observed in very green fruits.

In the tomato fruit catalase activity was lowest in very green fruits, much greater in the green mature stage, and became less in the ripe fruit.

Soil reaction and subsequent growth and yield had no apparent effect on oxidase activity, although oxidase activity was greater in the ripe fruits than in very green or green mature fruits.

Catalase and oxidase activity were apparently independent of each other.

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NEW AND LITTLE KNOWN NEOTROPICAL TINGITIDAE CARL J. DRAKE

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In the present paper two new genera, twenty-two species and one variety of Tingitidae are described from Mexico, West Indies, Central and South America. It is based upon material in the collection of the Carnegie Museum (Pittsburgh), Deutsches Entomologisches Institut der Kaiser-Wilhelm-Gessellschaft (Berlin-Dahlem), and the private collection of the writer. The writer is especially indebted to Doctors G. N. Wolcott, R. H. Van Zwaluwenburg, F. X. Williams, and Gregario Bondar for the gift of numerous specimens of Neotropical Tingitidae.

Nectocader, n. gen.

Head greatly prolonged, tumid, with four spines as in the genus Cantacader; bucculae very long, projecting considerably beyond apex of head, closed in front. Antennae long, slender; segments I and II swollen, short; III very long, slenderest; IV fusiform. Rostral channel very deep, long, open behind; rostrum extremely long, extending on the venter. Pronotum narrowed anteriorly, punctate, tumid, with five longitudinal carinae, the collum distinct. Paranota narrow, reticulate. Scutellum small, exposed, the posterior margin of pronotum not or scarcely produced. Elytra with a distinct clavus as well as costal, subcostal, discoidal and sutural areas; discoidal area very long, large, with prominent adventitious nervures; wings present.

Nectocader is most closely related to the genus Cantacader Amyot and Serville and belongs to the tribe Cantacaderia Stål. It may be distinguished from Cantacader by the more tumid head, subtruncate (either slightly excavated or slightly rounded) posterior margin of the pronotum and the exposed scutellum. Macropterous and brachypterous specimens are known to occur in one or perhaps two of the three described species.

Genotype, Nectocader (Cantacader) gounellei (Drake) from Brazil.

Nectocader germaini (Signoret)

Cantacader germaini Signoret, Ann. Soc. Ent., France, 1863, p. 586; Reed, Revista Chilena Hist. Nat. LV, 1902, p. — (reprint, p. 86).

Brachypterous female: Elongate-elliptical, body convex above, elytra (taken together) rounded behind. Margins of paranota and elytra serrate. Elytra a little longer than abdomen; costal area widest at base, uniseriate on distal half, with four to five rows of areolae at base and decreasing to one at middle, thence uniseriate; subcostal area very broad, with six to eight transverse costate nervures; discoidal area very large, long, with two prominent transverse nervures. Paranota narrow, composed of one

row of small round areolae, with two prominent teeth, one near the anterior end and the other at the middle. Rostrum reaching to the third venter. Antennae long, slender, the third segment distinctly shorter than in N.

tingitoides (Spinola).

Chile, six macropterous females, collected by the late Dr. Carlos Reed. On account of the wider subcostal area and shorter antennae, it seems advisable to treat this species as distinct, rather than to consider it the macropterous female of N. tingitoides. As Signoret and Reed have both pointed out, C. germaini and C. tingitoides are not typical species of the genus Cantacader Amyot and Serville.

Nectocader tingitoides (Spinola)

Piesma tingitoides Spinola, in Gay, Hist. Chile, Zool., VII, 1852, p. 200. Cantacader tingitoides Signoret, Ann. Soc. Ent., France, 1863, p. 575; Reed, Revista Chilena Hist. Nat. IV, 1902, p. — (reprint, p. 6).

A macropterous male from Chile is at hand. The antennae are about one-third longer than in the female specimens of N. germaini. The elytra are much longer than the abdomen. Germaini and tingitoides are very closely related, the former being based upon short winged females and the latter upon long winged males.

Nectocader gounellei (Drake)

Cantacader gounellei Drake, Bul. Brookl. Ent. Soc., XVIII, 1923, p. 81, fig. 1.

The extremely large size (6.4 mm. long and 3.6 mm. wide) and entirely uniscriate costal area distinguished this species at once from its congeners. The lateral margins of the paranota and elytra are not serrate. Known only from the type from Brazil.

Nyctotingis Drake, 1922

Nyctotingis Drake, Mem. Carn. Mus., IX, 1922, p. 362. Orthotype, Nyctotingis osborni Drake.

Nyctotingis osborni Drake

Nyctotingis osborni Drake, Mem. Carn. Mus., IX, 1922, p. 363, fig. 1.

The male (allotype) is very similar to the female in size, form, color, and appearance. The abdomen is narrowed posteriorly, black, the clasper being dark brown and strongly curved. Allotype (male), Mera, Ecuador, Feb. 2, 1923, collected by Mr. F. X. Williams, in my collection. Heretofore known only from the holotype (female), Chapada, Brazil, in the Carnegie Museum.

Genus Sphaerocysta Stål, 1873

Sphaerocysta Stål, Enum. Hemip., III, 1873, pp. 120 and 128. Logotype, Sphaerocysta globiffera (Stål).

Orifice long, prominent. Bucculae open or closed in front. Pronotum transversely swollen through the disc, punctate, uni- or tricarinate. Elytra

with a more or less prominent tumid elevation. Median carina either strongly raised and inflated at its apex or not raised at all. Discoidal area distinctly or indistinctly defined. Elytra a little longer than the abdomen. Nervures of hood, paranota and elytra moderately thick. Antennae and legs long, rather stout.

The pronotum is unicarinate in S. fumosa, n. sp. S. egregia, n. sp., differs from S. fumosa in having the paranota carina-like and non-reticulate behind and then expanded and reticulate in front; the median earina is neither raised nor inflated behind.

Sphaerocysta globiffera (Stål)

Tingis ? globiffera Stål, Rio Hemip., I, 1860, p. 65. Sphaerocysta globiffera Stål, Enum. Hemip. III, 1873, p. 128.

Several specimens, Bahia, Brazil, collected by Gregario Bondar; one female, Sana Cruz, Brazil. According to the original descriptions and the subsequent notes published by Stål, the type of S. globiffera has a very narrow and uniseriate paranota. This character separates it at once from its nearest ally, S. stali, n. sp.

Sphaerocysta stali, n. sp.

Form, size, color and markings very similar to *S. globiffera* Stål, but differing in having a little broader and biseriate paranota, slightly smaller hood, and a little broader costal area. Pronotal and head character very similar to *S. globiffera*; tumid elevation between discoidal and subcostal areas slightly smaller; costal area irregularly unit to biseriate, mostly uniseriate, with two rows at its widest part, the inner row very much smaller and mostly triangular in shape. Paranota narrow, strongly reflexed, biseriate, not widened behind. Rostrum reaching to the end of the mesosternum.

Length, 3.53 mm.; width, 1.35 mm.

Holotype, male, Rio Janeiro, in my collection. From the original description and notes in the Enumeratio Hemipterorum, it seems quite evident that Stål confounded this species with his S. globiffera. In fact, the type of S. stali was determined by Stål himself as S. globiffera. Champion (Trans. Ent. Soc. Lond., 1898, p. 59, pl. II, fig. 11) illustrated S. stali, n. sp. instead of the true S. globiffera Stål.

Sphaerocysta inflata biseriata, n. var.

Differs from S. inflata Stål in having the costal area of the elytra much broader and entirely biseriate. The hood also seems to be slightly smaller and the tumid elevations on the elytra are a little larger. Examination of the type of inflata may prove this insect to be a distinct species. Pronotum, head, antennae and paranota as in S. inflata.

Length, 3.53 mm.; width, 1.35 mm.

Holotype, male, Chapada, Brazil, in Carnegie Museum.

Paratype, male, taken with type, in my collection.

Sphaerocysta egregia, n. sp.

Yellowish brown, the elytra slightly lighter and with a small brown spot on each tumid elevation. Pronotum considerably swollen thru disc, coarsely pitted, somewhat shiny. Hood subglobose, not so strongly raised as in S. globiffera Stål. Carinae parallel, distinct, but feebly raised, the median becoming almost obsolete behind. Paranota almost obsolete behind, carina-like; expanded in front, uniseriate, the marginal nervure very thick, the areolae small. Head brown, with two short, testaceous spines in front, each directed downward and slightly inward. Bucculae not very broad, open in front. Rostrum reaching slightly beyond the middle of the mesosternum. Antennae moderately long and rather stout; segment I much stouter and not quite twice as long as two; III three times as long as four.

Elytra rounded behind; costal area broad, mostly biseriate, triseriate at its widest part, the areolae large; discoidal area distinct, with five areolae at its widest part, the tumid elevations very small; subcostal area mostly biseriate; triseriate at its widest part, the areolae slightly smaller than those of discoidal area. Wings almost as long as the elytra.

Length, 2.6 mm.; width, 1.36 mm.

Holotype, male, Corumba, Brazil, in Carnegie Museum. The median carina and paranota distinguish S. egregia, n. sp. from its congeners.

Sphaerocysta fumosa, n. sp.

Pronotum transversely swollen thru the disc, narrowed anteriorly, unicarinate, the lateral carinae wanting; median carina formed as in S. inflata Stål, with one large cell in front of the strongly inflated posterior portion. Paranota biseriate, narrowed in front, rounded, the outer row of arcolae very large. Hood subglobose, about the size and shape as in S. globiffera Stål, darker in color. Antennae with third and fourth segments wanting, the first segment a little over twice the length of the second. Elytra considerably longer than the abdomen, rounded behind; tumid elevations large, rounded, strongly inflated, costal area irregularly biseriate, arcolae large and not of a uniform size; some of the transverse nervures fuscous; subcostal area biseriate. Wings a little shorter than the elytra. Rostrum reaching to the end of the mesosternum.

General color testaceous, with fuscous markings; pronotum fuscous. Nervures of hood and inflated portion of elytra dark; areolae of paranota and costal and sutural areas somewhat iridescent, hyaline. Body beneath brownish black. Legs yellowish brown.

Length, 3.21 mm.; width, 1.59 mm.

Holotype, female, Para, Brazil, in my collection. This species is most closely allied to S. inflata Stål, but readily separated from it by the larger and more strongly inflated tumid elevation of the elytra and the unicarinate pronotum.

Zatingis, n. gen.

Head short, with five spines. Bucculae broad, reticulate, closed in front. Antenniferous tubercles prominent, broad, strongly compressed laterally. Antennae long, slender; segment I longer and much stouter than two, the latter very short; III very long, moderately stout; IV fusiform. Pro-

notum tricarinate, the triangular process long. Hood moderately large, narrow, roof-like, projecting angularly between eyes. Paranota moderately reflexed, the antero-lateral corner terminating in a long slender spine. Orifice indistinct. Metasternum wide, the intermediate and posterior coxae widely separated, the intermediate pair being placed far back on the mesosternum and almost touching posterior coxae. Nervures large and prominent. Elytra considerably longer than the abdomen, obliquely rounded at apex; costal, subcostal, discoidal and sutural areas distinct and bounded by prominent costate nervures; discoidal area reaching beyond middle of elytra, deeply impressed, surrounded by a very prominent costate nervure. Wings present. Legs rather short and stout.

Genotype, Zatingis extraria, n. sp.

This genus is most closely related to the genus *Hormisdus* Distant of the Philippines, from which it may be separated by the much shorter and stouter legs, stouter antennae, broad antenniferous tubercles, prominent hood and much thicker nervures. The hood extends back of the collum to the transversely swollen portion of pronotum; the median carina unites with the median nervure of hood.

Zatingis extraria, n. sp.

Elongate, brownish testaceous, with fuscous markings, the nervures prominent. Head reddish brown; median and posterior spines very long, slender and sharp, longer than the anterior ones. Antennae very long, rather slender; segment I considerably swollen, constricted a little beyond middle, dark brown, distinctly thicker and almost two and a half times as long as the second; III extremely long, slightly curved, a little less than five times as long as four; yellowish brown; IV fusiform, thickest a little beyond the middle, blackish, except the basal portion yellowish brown. Rostrum extending between intermediate coxae.

Pronotum transversely swollen thru disc, very coarsely pitted, reticulate behind, tricarinate; carinae parallel, long, each composed of a single row of rather large areolae. Paranota moderately broad, irregularly biseriate, the antero-lateral margin terminating in a long, sharp spine. Hood moderately long, narrow, distinctly \(^\)-shaped, highest in front, strongly projecting \(^\)-like in front. Elytra moderately expanded, subangulate at apex; costal area moderately wide, biseriate, the areolae irregular in size and arrangement; subcostal area quadriseriate, the areolae fairly regular in size and rows; discoidal area reaching beyond the middle of elytra, distinctly raised along the outer margin, impressed along the inner margin, bounded by a very prominent costate nervure, the outer margin arcuate, somewhat narrowed and raised at apex. Wings longer than abdomen. Claspers strongly curved in male.

Length, 3.03 mm.; width, 1.36 mm.

Holotype, male, S. Bernardino, Paraguay, in my collection. The long terminal antero-lateral spines of the paranota separate this insect from any known American species.

Leptodictya Stål, 1873

Leptodictya Stål, Enum. Hemip., III, 1873, pp. 121, 127; Champion, Biol. Centr. Amer., Rhynch., II, 1897, p. 23.
Logotype, Leptodictya ochropa Stål.

Leptodictya approximata Stål.

Monanthia approximata Stål, Rio Hemip., I, 1860, p. 63. Leptodictya approximata Stål Enum. Hemip., III, 1873, p. 127.

Female, Santa Paulo, Brazil, Jan. 28, 1923. This species has a much larger hood than *L. dohrnii* Stål or *L. ochropa* Stål. Antennae long, slender; segment I slightly thicker and less than twice as long as two, dark fuscous, concolorous with two and four; III long, slender, pale brown, two and a half times as long as four. Legs pale brown. Elytra widening posteriorly, prominently marked with dark fuscous, the tips separated, the lateral margins finely serrate.

Leptodictya vulgata, n. sp.

Form and size similar to *L. approximata* Stål. Antennae long, slender, black, clothed with bristly hairs; segment I a little stouter and practically twice as long as two; III very long, two and three-fourths times as long as four. Head with five long, porrect, sharp, testaceous spines, the median not quite reaching the tip of first antennal segment. Rostrum reaching to intermediate coxae. Legs long, slender, brownish fuscous, the tips of femora and tarsi blackish. Pronotum considerably swollen thru disc, dark brown to black, becoming testaceous on triangular portion, frequently covered (also head) with whitish exudations, tricarinate, each carina composed of a single row of small areolae; median carina a little more elevated and distinctly raised in front. Hood pale testaceous, rather large, considerably longer than wide, projecting anteriorly (between eyes) almost to apex of head. Paranota pale testaceous, sub-inflated, much wider beneath and more strongly reflexed than in *L. approximata*.

Elytra widening posteriorly, the tips separated, the outer margins finely serrate, the areolae hyaline; costal area broad, the areolae irregular in size and arrangement; testaceous, the outer half of four obliquely transverse nervures, the nervures forming marginal row of areolae and all nervures on distal half of elytra brown to fuscous, the marginal nervure dark fuscous; subcostal area pale testaceous, biseriate; discoidal area pale testaceous, long, narrow at base and apex, with four confused rows of areolae at widest part; nervures of sutural area fuscous. Male genital segments broad, the claspers strongly curved. Body beneath black.

Length, 4.71 mm.; width, 2.1 mm.

Holotype, male, Naranjapata, Ecuador, elevation 1800 ft., Dec., 1922, collected by F. X. Williams, in my collection; 3 paratypes (males), Huigra, Ecuador, elevation 4000 ft., collected by F. X. Williams. The color of antennae and semi-inflated and very strongly reflexed paranota distinguish this insect from L. approximata Stål.

Leptodictya championi, n. sp.

Moderately elongate, the color and markings similar to *L. cretata* Champion. Head black, spines testaceous; anterior pair longest, sharp, porrect, considerably shorter than the first antennal segment. Antennae long, slender, brownish black; segment I three times as long as two, the latter short; III very long, a little more than four times as long as four.

Pronotum slightly more tumid than in *L. cretata*; hood distinctly larger, more inflated and rounded, the median nervure fuscous; paranota more strongly reflexed, the turned over portion narrower, widest at middle, biseriate. Discoidal area much narrower, with four or five areolae at its widest part; other characters of elytra similar to *L. cretata*. Body beneath black.

Length, 4.41 mm.; width, 2.35 mm.

Holotype (male) Purula, Vera Paz, Guatemala, collected by G. C. Champion, in my collection. In the Biol. Centr.-Amer., II, 1897, p. 24. Champion confused this species with L. cretata Champ. from Panajachel. The shorter spines on the head, the dark antennae, larger and differently shaped hood and narrower discoidal area separate L. championi, n. sp., from L. cretata Champion.

Two cotypes of Champion's L. cretata from Panajachel are at hand; the paranota are not so strongly reflexed and wider than in L. championi, triseriate above, widest in front of middle. These paratypes agree with

the original description and figure of L. cretata.

Leptodictua madelinae, n. sp.

Similar to *L. championi*, n. sp. in size, color and form. Head with five moderately long, stout, blunt, testaceous spines; black, covered with white exudations. Antennae long, slender, brownish black; segment I stouter and twice as long as two, the latter considerably embrowned; III long, twice as long as four, the latter much longer than one and two conjoined. Pronotum black, coarsely pitted, more strongly swollen, the hood slightly smaller, and somewhat similar in form to *L. championi*; paranota slightly broader, mostly biseriate, sometimes with a few additional cells. Elytra a little darker than in *L. championi*; costal area unevenly reticulate; subcostal area irregularly biseriate; discoidal area long, narrow, impressed, with four somewhat confused rows of areolae at its widest part. Wings smoky, longer than the abdomen. Legs dark brown; tarsi black. Rostrum reaching to the intermediate coxae.

Length, 4.34 mm.; width, 2.34 mm.

Holotype, male, Banos, Ecuador, S. A., Jan. 8, 1923, collected by F. X. Williams, in my collection. Paratypes, 2 males, taken with type. The rostrum is much shorter and the fourth antennal segment (52) is much longer in this species than in L. championi (34).

Leptodictya williamsi, n. sp.

Narrower than L. grandatis, n. sp., the elytra marked with brown instead of dark fuscous. Head covered with whitish exudations, with five moderately slender spines, the anterior pair about one-third as long as the basal segment of antennae. Antennae long, slender, fuscous black; segment I a little stouter and twice as long as two; III nearly two and a half times as long as four. Hood much narrower than in L. grandatis, testaceous. Pronotum black, with whitish exudations, punctate, considerably swollen; paranota similar to L. grandatis, the margin touching the pronotum a little straighter. Median carina not as strongly raised anteriorly as in L. grandatis. Rostrum extending to the metasternum. Legs long, brown.

Elytra more widely reticulated than in *L. grandatis*, the costal and discoidal areas narrower; subcostal area biseriate, vertical; costal area irregularly and unevenly reticulated, with six to seven cells at its widest part. Wings smoky, longer than abdomen.

Length, 4.70 mm.; width, 2.00 mm.

Holotype, male, and allotype, female, Banos, 6000 feet elevation. Ecuador, Oct. 26, 1922, collected by Dr. F. X. Williams, in my collection. Five paratypes, taken with type. The nervures of sutural, subcostal and distal half of costal areas (also one or two rows along outer margin) are brown. The areolae are hyaline.

Leptodictya colombiana, n. sp.

Resembles L. williamsi and L. grandatis, but separated at once from them by the much smaller hood. Pronotum strongly swollen thru dise, coarsely punctate, tricarinate, each carina composed of one row of areolae. Hood very narrow, small, testaceous, projecting angulately anteriorly. Paranota biseriate above, mostly triseriate below, similar in shape to L. williamsi. Antennae blackish fuscous, segment I scarcely twice as long as two; III two and a half times as long as four. The median carina slightly more raised and considerably raised anteriorly. Head black, with five short spines. Elytra broad, testaceous, the nervures along the outer border and in distal half brown, the areolae hyaline, the outer marginal nervure larger, fuscous, and indistinctly serrate; subcostal area vertical, biseriate; discoidal area long, narrow, narrowed at base and apex, with four rows of areolae at its widest part. Legs brown, the tips of femora and tarsi black.

Length, 5.46 mm.; width, 2.99 mm.

Holotype (male), Colombia, S. A., March 11, 1912, H. S. Parish, in my collection. The very small and narrowly ∧-shaped hood distinguishes this species from its allies. Its hood is smaller and much narrower than in L. dohrnii Stål.

Leptodictya sodalatis, n. sp.

Large, yellowish brown, some of the veinlets and transverse veins dark brown or fuscous, the areolae hyaline. Form similar to *L. leinahoni* Kirk., but much smaller, lighter in color, the hood very much smaller. Head brown, with five very long, sharp, testaceous spines, the anterior pair reaching a little beyond the second antennal segment. Rostral channel deep, slightly widening posteriorly, the rostrum reaching almost to the end of the channel. Antennae long, slender, pale brown; segment I rather long, a little less than four times as long as two; II very short; III very long, more than five times as long as one; IV long, subequal to one in length, the distal five-sixths fuscous or black.

Pronotum strongly narrowed anteriorly, brown, moderately swollen thru the disc; strongly narrowed anteriorly, punctate; carinae parallel, each composed of a single row of minute areolae, the median carina more strongly rasied and biseriate in front. Paranota very broad in front, much narrower behind; outer margin nearly straight, armed with a few spines; reflexed portion composed of a single row of large rectangular areolae: in front composed of five rows of cells. Hood narrow, small, \(\Lambda\)-shaped as

viewed from above, projecting faintly over the base of the head. Collum distinctly areolate, the calli smooth and shiny. Body beneath brown. Elytra broad, much longer than the abdomen, broadly rounded at the apex; the lateral margins slightly rounded, bluntly serrate, each small tooth-like protuberance terminating in a stiff bristle-like hair; costal area brown, with many confused rows of large arcolae (seven or eight rows at widest part); with three or four cross nervures somewhat costate and fuscous: discoidal area long, extending beyond the middle of the elytra, with six rows of arcolae at its widest part, the sides slightly rounded, the adventitious nervure short, running a little beyond the middle obliquely across discoidal area; nervure separating areas with erect, moderately long hairs, the other nervures with a few scattered haris. Wings greatly reduced.

Length, 4.9 mm.: width, 2.8 mm.

Holotype (male) and allotype (female), Cochahamba, Bolivia, in my collection. Paratype, four specimens, collected with type. Two paratypes in collection of Deutsches Entomologisches Institut der Kaiser-Wilhelm-Gessellschaft.

Leptodictya luculenta, n. sp.

Elongate, broad, pale cinnamon brown, the paranota and costal area a little lighter, areolae hyaline. Head brown, tumid, with very long sharp spines, the posterior pair very long. Rostral channel widening posteriorly, open behind; rostrum reaching a little beyond the mesosternum. Paranota moderately broad, the reflexed lateral margin slightly emarginate; overlapping portion broadest in front of middle, biseriate, the outer margin rounded and resting on pronotum. Pronotum considerably swollen thru disc, deeply and coarsely pitted, becoming reticulate in triangular portion, tricarinate, each carina composed of a single row of small areolae; median carina more strongly raised, biseriate in front; lateral carinae parallel, slightly less raised. Hood \(\Lambda\)-shaped, projecting faintly in front, larger than in \(L.\) dohrnii Stål.

Elytra broad, rounded behind, the tips separated; costal area very broad, with two or three large transverse nervures, with five to six rows of areolae at its widest part, the areolae moderately large and a little variable in size and arrangement; subcostal area very narrow, uniseriate; discoidal area long, narrowed at base and apex and composed of six rows of small somewhat rounded areolae at its widest part. Body beneath dark brown, becoming darker on genital segments. Legs long, rather slender, brown, the tips of tarsi dark. Antennae long, slender, brown; segment I a little stouter, two and one-half times as long as two; III very long, slightly more than twice as long as four; IV becoming black on the distal two-thirds, clothed with numerous pale hairs.

Length, 4.44 mm.; width, 1.78 mm.

Holotype, male, and allotype, female, Mera, Ecuador, collected by F. X. Williams, in my collection. This species resembles L. evidens, n. sp., from which it may be separated by the characters given below.

Leptodictya evidens, n. sp.

A little broader and slightly lighter in color than L. luculenta, the paranota, inner portion of costal and sutural areas and discoidal area

mostly brownish testaceous. Head reddish brown, the spines moderately long, sharp, brownish testaceous; anterior spines reaching a little beyond the middle of first antennal segment. Antennae long, brown; segment I twice as long and a little stouter than two; III three times as long as four, the latter blackish and clothed with pale brown, carinae parallel, other characters as in L. luculenta. Hood considerably larger, broader, and a little more produced than in L. luculenta. Rostrum extending almost to apex of sulcus. Paranota formed somewhat as in L. approximata Stål, mostly biseriate, a few extra cells at its widest part, the outer reflexed margin rounded. Elytra very similar to L. luculenta, but a little broader, more broadly rounded behind and lighter in color; wing reaching to tip of abdomen.

Length, 4.41 mm.; width, 1.89 mm.

Holotype, female, Tabernilla, Panama, in my collection. Paratype, females, taken with type. The much larger hood and rounded outer reflexed margins of the paranota distinguish this species from L. luculenta. n. sp.

Leptodictya formosatis, n. sp.

Head black; median and anterior spines rather short, blunt, testaceous, porrect; posterior pair sharp, a little longer, contiguous with the head. Antennae long, brownish black; segment I moderately long, constricted a little beyond the middle, stouter and not quite twice as long as two; III long, not quite three times as long as four; IV longer than one and two taken together, the hairs pale, much thicker and longer. Rostrum reaching almost to the apex of sulcus. Pronotum very strongly swollen thru dise, coarsely punctate, black, shiny, tricarinate, each carina composed of a single row of very small areolae. Paranota narrow, reflexed margin rounded and fuscous, the distal portions of anterior and posterior femora, anterior tibiae and tarsi black.

Elytra prominently marked with fuscous, the marginal nervure fuscous. broadly rounded at apex; costal area broad, the areolae very irregular in size and arrangement, with six or seven areolae at its widest part, brown, a few areolae at base and two to three rows along subcostal area; the rest of the surface brown except four depressed oblique nervures and areolae in these depressions, the other areolae hyaline; subcostal area biseriate, brown at base and becoming testaceous toward apex; discoidal area long, broad, dark fuscous, an indistinct spot beyond middle and a spot at apex testaceous; nervures of sutural area dark fuscous; the areolae subhyaline. Wings scarcely longer than abdomen.

Length, 5.51 mm.; width, 2.6 mm.

Holotype, female, and allotype, male, Mera, Ecuador, Feb. 2, 1923, taken by F. X. Williams, in my collection. Paratype, female taken with type. Allied to L. approximata Stål, but distinguished by smaller hood, more swollen pronotum, broader discoidal area and more prominent color markings.

Leptodictya fusca, n. sp.

Moderately large, dark fuscous, the paranota and hood lighter. Antennae long, slender, dark testaceous; segment I dark fuscous, a little

thicker and about one and a half times as long as two; III very slender, straight, long, a little less than three times as long as four. Rostrum extending to the metasternum. Bucculae closed in front. Head short, black.

with five long, slender, sharp spines,

Pronotum strongly swollen thru disc, coarsely pitted, reticulate at apex, tricarinate; carinae parallel, thin, each composed of a single row of very small cells. Hood moderately large, projecting subangularly in front. Paranota with two to three rows of areolae on the reflexed portion. Elytra broadly expanded, rather indistinctly serrate along the outer margins, entirely dark fuscous in color; costal area very broad, with four enlarged oblique nervures, about nine or ten areolae at its widest part, the areolae not definitely arranged in rows; subcostal area narrow, biseriate; discoidal area very long, narrowed at base and apex, reaching beyond the middle of clytra, without adventitious nervures, with six to seven rows of areolae at its widest part. Wings a little shorter than elytra. Body beneath dark yellowish brown. Legs pale testaceous, the tarsi darker.

Length, 3 mm.; width, 1.8 mm.

Holotype, male, Panama Canal Zone, in my collection. The dark fuscous color (areolae clouded with fuscous) separates this species from allied forms. A small area at the widest part of costal area has a tendency to become a little paler.

Australotingis Hacker, 1927

Australotingis Hacker, Mem. Queensland Mus., IX, 1927, p. 29. Orthotype, Australotingis franzeni Hacker.

Australotingis williamsi, n. sp.

Very broad, blackish fuscous, the expanded portion of elytra yellowish brown and with prominent, broad, oblique, fuscous bands. Head, pronotum, hood, paranota, and discoidal and subcostal areas of elytra with whit ish exudations. Bucculae prominent, reticulate, closed in front. Head short, black, the three frontal spines long, sharp, dark brown; posterior spines much shorter and slenderer. Antennae long, slender, clothed with a few long hairs; segment I rather stout, a little shorter than the distance between eyes, slightly curved, slightly constricted before apex, brownish black; II practically one-half the length of one, brownish black; III long. slender, a little more than twice as long as four, almost straight, brownish. slightly darker at base and the apical one-fourth blackish; IV long, slightly stouter than III, clothed with numerous hairs of various lengths, twice as long as one. Antenniferous tubercles greatly flattened laterally, wide, not Rostral channel open behind; rostrum broken, apparently reaching a little beyond the intermediate coxae. Orifice prominent. Legs dark reddish brown, the tarsi black. Body beneath black, the last segment of venter and genital segments somewhat embrowned. Hood, pronotum. paranota and elytra clothed with numerous long, very fine, erect or nearly crect, whitish to vellowish white hairs.

Pronotum transversely swollen thru disc, coarsely punctate; tricarinate; lateral carinae parallel, long, prominent, about one-third as high as the median, composed of one row of arcolae; median carina strongly foliaceous, composed of a single row of long rectangular arcolae. Hood mod-

erately large, strongly inflated, extending over base of head, not twice as high as the median carina. Paranota long, strongly inflated, hood-like in appearance, the hairs more numerous along the sides, the outer margin resting near the lateral carina. Elytra broad, broadly rounded behind, the tips separated. Costal area broad, with three depressed, slightly oblique, fuscous bands (both nervures and areolae fuscous), with six to seven rows of areolae at its widest part, very irregularly reticulate; subcostal areas biscriate; discoidal area long, extending almost to apex of abdomen, narrowed at both base and apex.

Length, 5.14 mm.; width, 2.41 mm.

Holotype, female, Mera, Ecuador, Feb. 2, 1923, F. X. Williams, collector, in my collection. Named in honor of Dr. Williams, who has collected a large number of interesting Tingitidae in South America. This is the first record of this genus in America, recorded heretofore only from Australia.

Genus Leptopharsa Stål, 1873

Leptostyla Stål, Enum. Hemip., III, 1873, pp. 120 and 125.
Leptopharsa Stål, Enum. Hemip., III, 1873, pp. 122 and 126.
Gelchossa Kirkaldy, The Entomologist, XXXVII, 1904, p. 280.
Leptostyla Champion, Biol. Centr.-Amer., Rhynch., II, 1897, p. 11.
Leptopharsa Champion, Biol. Centr.-Amer., Rhynch., II, 1897, p. 21.
Gelchossa Drake, Mem. Carn. Mus., IX, 1922, p. 372.
Leptopharsa Drake, Mem. Carn. Mus., IX, 1922, p. 370.
Leptopharsa Drake, Proc. Biol., Soc. Washington, Vol. 41, 1928, pp. 21-24.

Leptopharsa tenuatis n. sp.

Elongate, very slender, testaceous, the disc of pronotum and some of the veinlets of sutural area brown. Head black, short; posterior spines long, slender, curved, testaceous; median spine stouter, straight, porrect, sharp; anterior pair wanting. Rostral sulcus closed behind, the rostrum extending to the middle of mesosternum. Pronotum slightly swollen thru disc, moderately narrowed anteriorly, distinctly pitted; triangular process long, testaceous, reticulate; tricarinate, each carina uniseriate, testaceous, the lateral ones slightly converging posteriorly. Paranota strongly reflexed, testaceous, narrow, biseriate, the basal row of cells very small. Hood very small, very narrow, faintly projecting anteriorly.

Elytra long, very narrow, the lateral margins nearly straight; costal area reflexed, moderately wide, biseriate; subcostal area much narrower, biseriate; discoidal area elongate, with three to four rows of arcolae at its widest part. Wings smoky, much longer than the abdomen; legs long, slender, brownish testaceous. Antennae very long, slender; segment I very long, fuscous, almost four times as long as two, broadly constricted near apex; II short, fuscous; III very long, pale brown. Body beneath black.

Length 3.00 mm.; width, .71 mm.

Holotype, male, Brazil, in my collectoin. This species is most closely allied to L. longula Drake, L. manihotae Drake and L. illudens Drake, but differs in the characters of antennae, spines on head, and pronotal carinae. It is also shorter than L. longula.

Leptopharsa distantis n. sp.

Moderately elongate, testaceous; the head and pronotum brownish. Head with five moderately stout, blunt, pale brown spines, the posterior pair curved inwardly and contiguous with the head; the median and anterior pair directed obliquely downward. Segment I of antennae thicker and slightly more than twice as long as two; III and IV wanting. Rostral channel widening posteriorly, very wide on the metasternum; rostrum extending to the intermediate coxac. Hood very small, faintly projecting in front, somewhat transverse.

Body beneath black. Legs moderately long, yellowish brown, the tarsi darker. Pronotum moderately swollen thru disc, coarsely pitted, the apex of triangular process yellowish; lateral carinae faintly converging in front and behind, indistinctly areolate; median carina slightly more elevated, composed of a single row of tiny areolae. Paranota moderately expanded, slightly reflexed, biseriate, the outer margin broadly rounded. Elytra considerably longer than abdomen; rounded behind; costal composed of two regular rows of large areolae; subcostal area about as wide, but composed of four rows of small areolae; discoidal raised, extending beyond middle of elytra, narrowed at both base and apex, with five or six rows of areolae at its widest part, the areolae a little larger than those of subcostal area. Wings a little shorter than the elytra.

Length, 2.51 mm.; width, 1.14 mm.

Holotype, male, Tamasopa, Mexico, Dec. 4, 1909, in my collection. This species belongs to the division of the genus Leptopharsa Stål, having a transverse hood. It is shorter and broader than L. elegantula Stål.

Leptopharsa celebratis, n. sp.

Elongate, narrow, becoming a little wider posteriorly. Head short, black; posterior spines very short, blunt, testaceous, resting on the head; other spines wanting. Antennae long, slender, fuscous-black; segment I slightly constricted a little beyond the middle, moderately long, considerably stouter and a little more than twice as long as two; III very long, slender; IV wanting. Bucculae contiguous at the base in front. Rostrum rather short, reaching to a little beyond the prosternum.

Pronotum considerably swollen thru disc, coarsely and deeply pitted. narrowed anteriorly, tricarinate, black; median carina raised in front from ing a small transverse hood; lateral carinae practically parallel, faintly curved inwardly in front. The apex of triangular portion and carinac somewhat tinged with testaceous. Paranota narrow, testaceous, slightly reflexed, the outer margin straight, a little wider and biseriate in front, uniseriate behind, the areolae rather small. Elytra rounded behind, nervures separating areas costate, prominent, and tinged with dark reddish brown; costal area testaceous, moderately broad, composed of two complete rows of areolae and a partial third series at its widest part, the areolae moderately large and sub-hyaline; subcostal area biseriate, nearly vertical. black; discoidal area long, narrowed at base and apex, widest at the middle. and there with five rows of arcolae, black; sutural area with the arcolae becoming larger distally, brownish black. The areolae of subcostal, discoidal and sutural areas whitish or smoky, non-transparent. Legs long. rather slender, reddish brown, the tip of tarsi darker.

Length, 3.51 mm.; width, 1.14 mm.

Holotype, male, and allotype, female, Rio Grande du Sul, Brazil, in my collection.

Leptopharsa calopa, n. sp.

Moderately elongate, narrow. Head short, black, with five long, slender porrect spines; median and anterior spines very long and brown, the posterior pair shorter and whitish. Rostral channel widening posteriorly. open behind, the rostrum not quite extending to the middle of the mesosternum. Legs slender, testaceous, the tarsi brown. Antennae very long. slender, testaceous; segment I short, slightly stouter and twice as long as two, tinged with brown; III very long, two times as long as four; IV long. twice as long as one and two conjoined.

Pronotum considerably swollen thru disc, coarsely pitted, smooth, brownish black, the posterior process pale testaceous and reticulate. very small, pale testaceous, projecting sub-triangularly in front. foliaceous, pale testaceous, uniscriate; median carina slightly more raised; lateral carinae, long, faintly constricted behind the disc. Paranota moderately wide, entirely biseriate, the basal row of areolae very small. considerably longer than abdomen, rounded behind, the tips separated, the nervures fuscous, except the basal two-thirds of costal area pale testaceous; costal area biseriate at base, thence triseriate; subcostal area narrow, subvertical, biseriate; discoidal area narrow, narrowed at both base and apex. impressed, not guite reaching the middle of elvtra; wings about as long as the abdomen. Body beneath black.

Length, 2.59 mm.; width, 1.12 mm.

Holotype, male, Chapada, Brazil, collected by H. H. Smith, in Carnegie Museum. This species resembles L. divisa (Champion), but may be separated from it by the longer antennae and costal area of elytra.

Leptopharsa distinconis, n. sp.

Head with a stout, blunt, strongly curved downward, median spine. Bucculae closed in front, the rostrum reaching to the end of the rostral Antennae very long, slender, indistinctly pilose; segment I very long, five times as long as two, very widely constricted in front of apex, brownish black; II and III testaceous, the latter not quite one and a half times as long as four; IV very long, slender, brownish black, longer than

one and two conjoined. Legs long, slender.

Pronotum black, becoming lighter toward apex of triangular process. moderately swollen on disc; median carinae very strongly raised, long, nearly twice as long as hood, broadly arched above, at its highest point more elevated than hood, composed of one row of very long rectangular areolae. Hood moderately large, not extending to the middle of the disc. projecting anteriorly to the apex of head, the eyes not concealed. Lateral carinae strongly foliaceous, long, constructed behind middle, each composed of a single row of large areolae. Elytra long, divergent, widening posteriorly, constricted beyond the middle, rounded at the tip; areolae hyaline, the costal area broad, with four or five somewhat irregular rows of areolae at its widest part; subcostal area vertical, mostly triseriate; discoidal area short, not reaching middle of elytra, narrowed at both base and apex. Nervures of discoidal, subcostal, three or four oblique nervures of costal area, and a long oblique curved fascia (including cells) extending from just behind discoidal area to tip of each elytron, dark brown. Wings slightly longer than abdomen.

Length, 3.52 mm.; width, 1.40 mm.

Holotype, male, and allotype, female, Chapada, Brazil, collected by H. H. Smith, in Carnegie Museum. Paratypes, 11 specimens, collected with type, in Carnegie Museum and my collection. This species is most closely allied to L. vesiculosa (Champ.), from which it differs in the characters of the hood, paranota, and carinae.

Leptopharsa peruensis, n. sp.

Form and general appearance similar to *L. distinconsis*, n. sp.; color much darker, the nervures brown to fuscous. Antennae very long, slender; segment I very long, attenuated toward apex, five times as long as two, black; III testaceous, nearly one and three-fourths times as long as four, the latter very long and black. Head black, the median spine projecting almost directly upward, moderately long. Hood large, dark, slightly longer than high, not projecting as far forward as in *L. distinconsis*. Pronotum black, the triangular portion short and narrow; median carinae very strongly foliaceous, not quite as high as hood, composed of one row of very long, rectangular areolae; lateral carinae considerably raised, uniseriate, slightly constricted behind the middle.

Elytra widening posterioly, divarieating behind, with a prominent depressed, oblique, fuscous band at the apex of costal area; costal area broad, with five irregular rows of areolae at its widest part; subcostal area almost vertical, triseriate; discoidal area short, strongly raised toward the outer margin, almost triangular, the posterior margin almost oblique. Wings searcely as long as abdomen. Body beneath black. Legs long, slender,

vellowish brown.

Length, 3.57 mm.; width, 1.46 mm.

Holotype, female, Peru, in my collection. The dark veins, hood, and discoidal area distinguish this insect at once from the species having a very long basal segment of antennae. The paranota are large, strongly reflexed, widest opposite humeri and each is composed of three rows of large areolae.

Leptopharsa walcotti, n. sp.

Allied to L. tumida (Champion), but larger and with the median carina strongly and sharply arched behind the hood. Antennae long, testaceous; segment I long, slightly stouter and three times as long as two; III a little more than three and a half times as long as four. Hood very large, strongly inflated, not concealing carinae. Paranota very wide, strongly reflexed, with five rows of areolae at its widest part, the anterior and posterior margins slightly recurved; lateral carinae extremely short, each somewhat resembling a long spine, not concealed by the hood. Elytra widening posteriorly, the tips separated, similar in shape to L. tumida, the long oblique curved fascia faintly colored, the areolae hyaline; costal area widely reticulated, with four rows of areolae at its widest part. Rostral channel open behind, the rostrum extending to its apex. Lateral margins of elytra finely serrate.

Length, 3.7 mm.; width, 1.73 mm.

Holotype (male), and allotype (female) Gonaivets, Haiti, Feb. 19, 1900, collected by G. N. Wolcott, in my collection. Paratypes, 9 specimens, taken with type. This insect is named in honor of Dr. Wolcott, who has taken a keen interest in the insect fauna of Haiti.

Leptopharsa cubana, n. sp.

Very similar in form, color and appearance to *L. tumida* (Champion), but much smaller and with the median carina exposed and distinctly arched behind the hood. Hood moderately large, about one-half as large as in *L. wolcotti*; paranota similar in form, but much smaller, with three or four rows of areolae at its widest part, the outer margin finely serrate; subcostal area vertical, mostly biseriate. Head with the median spine porrect, straight, much longer and stouter than the others. First segment of antennae brownish, stouter and three times as long as two; III and IV wanting. Rostrum reaching to the end of the rostral groove.

Length, 2.44 mm.; width, 1.19 mm.

Holotype, male, and allotype, female, Peninsula de Guanahacabibes, Cuba, 1924, in my collection. The color and markings of this species are quite similar to L. tumida; the different median carina and the smaller hood separate it at once from either L. wolcotti or L. tumida.

THE FERMENTATION OF CORNSTALKS AND THEIR CONSTITUENTS*

I. Studies on the Pectin-Fermenting Bacteria**.

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Organisms capable of fermenting pectin or related compounds in plant tissues have been studied principally by investigators interested in the retting of flax, hemp, and other plants. These studies have been made in a large measure from the standpoint of commercial retting. In only a few cases has any attention been paid to the systematic relationships of the organisms producing the change.

A Committee on Nomenclature of Pectin (1927) has recommended the use of the name "pectin" for the soluble compound and "protopectin" for the insoluble compound occurring in plant tissue. In referring to these

substances in plant tissue the term "natural pectin" will be used.

The use of plant tissue as a substrate for the isolation and identification of pectin-fermenting bacteria has proved to be an unreliable procedure due to variation in content and in composition of the natural pectin in different plants. Furthermore, the disintegration of plant tissue when acted upon by these bacteria may be influenced by other factors, such as the maturity of the plant and the absence of suitable conditions for the growth of the organisms.

The use of a chemically pure pectin for the isolation and identification of pectin-fermenting bacteria should prove advantageous over the use of plant tissue. At present pectin may be obtained which is approximately pure and is reasonably constant in composition. It may not be identical with the pectin as it occurs in plant tissue, but its use makes possible an

improvement in technique.

The early investigations of pectin date from the discovery and naming of pectin by Braconnot (1825), who separated it from fruit juices. Payen (1856) and Mangin (1889) studied the pectin which occurs naturally in plant tissue. They concluded that pectin in some form constitutes a large part of the middle lamella. Later Mangin (1893) showed the effect of acids and alkalies on the natural pectin in plant tissue. He also studied the solvent action of ammonium citrate, oxalate, tartrate, and the salts of other organic acids. These he observed to form double salts with the pectin. He concluded that the middle lamella of plant tissue consisted largely of a

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calcium salt of pectic acid. Furthermore, he showed the middle lamella to be stained by ruthenium red, in this respect resembling many plant slimes and gums. Beijerinck (1904) referred to the natural pectin as pectose. Tschirch (1908) separated a material which he considered to be the mother

substance of pectin and named it protopectin.

Studies on the fermentation of pectin date from the discovery of the enzymes pectase and pectinase. The former was obtained by Frémy (1848). It caused the gelation of the pectin solution. The gel formation was considered to be due to the hydrolysis of pectin to pectic acid. Later, Bertrand and Mallérve (1894) showed that pectase is widely distributed among vegetables. Their investigations further indicate that gel formation is influenced by acidity and the presence of a salt of calcium, barium or strontium. Von Fellenberg (1918) has recently shown that sucrose is nec-

essary for the gel formation in fruit juice.

Another important enzyme connected with the fermentation of peetin is pectinase. This was identified in malt extract by Bourquelot and Hérissey (1898). It hydrolyzes pectin with the formation of simple sugars and acids. The work of Beijerinek and Van Delden (1903) showed it to produce marked retting of plant tissue. They termed it pectosinase. It is probably identical with the pectinase isolated by Bourquelot and Hérissey (1898). Later studies on the pectin-fermenting enzyme by Jones (1905) and others have shown that the organisms causing the soft rots of vegetables produce pectinase capable of attacking the natural pectin of the middle lamella. However, if the name "protopectin" is to be used for the insoluble pectin occurring in plant tissue, the enzyme attacking such substance may well be called protopectinase.

The relation of pectin fermentation to the retting of flax and hemp was recognized by Kolb in 1868. He showed that the fibers of plants were held together by the natural pectin corresponding to the pectose studied by Frémy (1848), and that the fermentation occurring during the retting process resulted in the formation of pectic acid. He believed retting to be the result of the fermentation of the natural pectin. However, other investigators interpreted their results as showing that retting was the result of cellulose decomposition. In 1877 Van Tieghem isolated an organism which he named Bacillus amylobacter and which he believed to be responsible for the retting of plant stems because of its ability to decompose cellu-Mangin (1891) concluded the natural pectin to be associated with cellulose in the plant and considered the fermentation of pectin to be correlated with that of cellulose. Winogradsky and Fribes (1895) showed that the loss in weight of flax stems and sugar beet slices following the retting fermentation corresponded very closely to the original pectin content. Furthermore, they showed that the cellulose of plant stems was unchanged as the result of the usual retting process. Their results confirmed the findings of Kolb and established pectin fermentation as the fundamental process of the retting of flax.

Behrens (1902) studied the condition favorable for retting of hemp and the organisms concerned. He found that best results were obtained when the amount of hemp was small compared to the volume of solution and when lime was present to neutralize any acids formed. Retting by pure cultures was observed only upon the exclusion of air. The active retting agent he believed to be an anaerobe of the type of *Bacillus amylobacter*

found in soil. Commonly associated with this anaerobe was an aerobic organism, Bucillus asterosporus. He concluded the retting loosened the plant fibers by dissolving the natural pectin. Störmer (1904) secured similar results with flax, but found the organism to be a plectridium. The products of the pectin decomposition were H2, CO2, and certain organic acids. The acids consisted principally of acetic and butyric, with a small amount of valeric and lactic. Beijerinck and Van Delden (1904) isolated certain bacteria which were active in the retting of hemp. These bacteria were shown to attack pectose (protopectin) by means of the enzyme pectosinase. The fermentation of the natural pectin of hemp resulted in the formation of pentose sugars, butyric acid, H2, and CO2. They named the organisms producing this enzyme Granulobacter pectinovorum and G. urocephalum. They were described as anaerobes of the clostridium type. They readily fermented starch, inulin, mannitol, erythritol, glycerol, and gum arabic in addition to the simple sugars.

In the more recently developed methods of retting extensive use has been made of pure cultures of bacteria. The Rossi (1916) process involves the use of *Bacillus comesii*, together with the microorganisms naturally occurring in the material to be retted. This organism is an aerobe similar to *Bacillus asterosporus* described by Meyer (1897). The Carbone process is based on the use of a retting organism in pure culture with an incubation temperature of 35°-39° C. The organism *Bacillus (Clostridium) felsineus* (1922) is an anaerobe. It produces a distinct digestion of potato. In ret-

ting, this organism is grown with Saccharomyces ellipsoideus.

Another phase of pectin fermentation of practical significance has been studied by those interested in the spoilage of vegetables. One of the first studies in this field was made by Jones (1901) in a study of Erwinia carotovora, the cause of soft rot of carrots and other root crops. This led to numerous investigations on the rotting of vegetables. The pectolytic enzyme was studied in detail. It was found to destroy the middle lamella of carrots, causing the cells to separate. The action of pectinase was favored by a temperature of 40°-45° C, and the presence of small amounts of acid. However, the strong acidity of certain plant juices was sufficient to retard its action. A two percent solution of alkali also inhibited the action of pectinase. It acted vigorously on pectin, but not on true cellulose or hemicellulose. It was suggested by Jones that many organisms producing a similar softening of fleshy roots produce pectinase. Harding and Stewart (1902) studied softening of plant tissues by Erwinia carotovora, Pseudomonas campestris and other organisms. Jones (1905) suggested the only logical means of classifying these organisms was on the basis of the enzymes produced. The organisms causing the soft rots of vegetables are in general pectin fermenters. They grow best at about 30° C. and are gram negative non-spore bearing rods.

Harter and Weimer (1921) compared the production of pectinase of different species of *Rhizopus* with the softening which they produced in sweet potatoes and found marked variations. Pectinase appeared to be an

extra-cellular enzyme.

Earlier work concerning the presence, amount and location of pectin in plant tissue was carried out largely by the use of certain dyes and chemical reagents. Such investigators as Mangin (1893), Van Wisselingh (1898), and Tschirch (1908) have been active in this field of work and are

largely responsible for the methods of procedure which are followed in this kind of investigation. Probably the most important reagent for this work is the ruthenium red dye which colors the pectin in the tissues red. The disadvantage, however, in its use is that similar staining reactions are given by lignin, glycogen, and isolichenin. Consequently, many investigators, particularly in recent years, have made quantitative determinations of the pectin content of plant tissue by means of extraction methods. This procedure can be considered as giving approximate results only, since the

yield of pectin varies with the method of extraction.

Confusion arising from different methods of extraction, the extent of purification, and the source of the pectin has rendered difficult the determination of its chemical structure. Earlier investigators recorded its physical and chemical properties. A few of these workers such as Frémy (1848), Payen (1856) and later Carré (1922) considered the pectin to be present in the plant as a calcium salt of pectic acid. Tollens (1895) in a study of the composition of pectins from different sources showed that it contained acid radicals. Ehrlich (1917) recognized d-galacturonic acid to be an important constituent of the pectin obtained from many different fruits and plant tissues. He also showed galactose and arabinose to be contained in pectin and concluded the natural pectin to be a calcium-magnesium salt of a complex anhydro-arabino-galacto-methoxy-tetralacturonic acid.

Von Fellenberg (1918) considered the natural pectin (pectose, protopectin) to be a completely methylated ester of pectic acid. He came to this conclusion after he was able to saponify the pectose with the liberation of methyl alcohol. He further concluded that methoxyl groups were present in the pectin molecule. He observed variations in the pectins obtained from different fruits and concluded that the pectin content of older tissue decreased as the lignin content increased. Correns (1921) in work on the nataral pectin of flax showed that the solubility of the pectin decreased with the increased methoxyl content. Ritter and Fleck (1923), and Ritter (1925) in studies made of spring and summer woods observed the increase in lignin in the summer wood at the expense of the pectin. F. Ehrlich (1927) also recognized this relationship between pectin and lignin. He considered that pectin might be transformed into lignin during the maturing of the Sucharipa (1924) studied the relation of pectin to the cellulose in plant tissue. He obtained the pectin from lemon peel. After removing all soluble pectin and cellulose by suitable reagents, he demonstrated that additional pectin and cellulose could be developed by hydrolysis. He concluded from this work that pectin and cellulose are intimately combined when occurring naturally in the plant.

Recent progress in our knowledge of the chemistry of pectin has resulted in several proposed structures for the pectin molecule. Ahmann and Hooker (1925) after studying the hydrolytic products of pectic acid propose the following formula for the Bausteine of this compound:

$$(COOH)O_3H_7C_5 < {\stackrel{\textstyle O}{\scriptstyle O}} > C_5H_9O_3(COOH)$$
 (Galacto-galactonic acid.)

Peetic acid, they state, contains at least six of these groups and probably These are linked together in the form of a ring. Pectin would be represented by covering the carboxyl groups with methyl groups. chemical structures suggested by Nanji, Paton, and Ling (1925) and as reported by Dore (1926) postulates a hexa-ring structure for pectin. Four sides of the hexagon nucleus are made up of d-galacturonic acid groups. The fifth and sixth sides consist respectively of a molecule of galactose and one of arabinose. In a demethylated pectic acid this provides four carboxyl groups. Norris and Schyver (1925) have accepted this structure and conclude that in the natural pectin the hydrogen of three of the carboxyl groups only are replaced by methyl groups. The remaining carboxyl may unite with a base or other substance in the plant. Ehrlich (1927) studied natural pectin from sugar beets and was able to show d-galacturonic acid to be the nucleus of the pectin molecule. By producing partial hydrolysis of the protopectin, Ehrlich was able to prepare several poly-galacturonic acids. He concluded that tetra-galacturonic acid constitutes a large part of the pectin molecule, which in addition contains a molecule of galactose and one of arabinose. The natural pectin in the beet was hydrolyzed to a pectic acid, which was conceived as a tri-acetyl-arabino-galacto-dimethoxytetragalacturonic acid.

The work of many investigators thus seems to have demonstrated several possibilities as to the composition of pectin and its combination with other substances in plant tissue. Its composition has been shown to vary with different plants, in the different parts of the same plant, and with the stage of growth. Since these qualifications are necessary concerning the pectin present in plant tissue the use of such a tissue for the identification or isolation of pectin-fermenting bacteria may prove to be unreliable. An organism found to produce retting or maceration in plant tissue may not necessarily be capable of fermenting pectin. On the other hand, the organism capable of fermenting pectin may be incapable of producing retting or maceration of plant tissue.

Earlier investigations have emphasized the importance of pectinfermenting bacteria largely in relation to the retting of fiber plants and to the rotting of vegetables. However, Kruse (1910) refers to many investigators who have designated such common organisms as *Bacillus subtilis*, *Bacterium coli*, and others as pectin-fermenters. Behrens (1902) had previously attempted to cultivate pectin-fermenting bacteria from retting

hemp by use of an extract from the middle lamella as a medium.

More recently investigations of the pectin-fermenting bacteria have been made as to the systematic relationships, their distribution in nature. and the chemical changes they induce in pectin. Due to the increasing interest in this field of work and because of the improved methods in the preparation of pectin, this substance is finding use as a substrate in the study of many different groups of bacteria. Makrinow (1915) used pectin in the study of a soil organism which he named Pectinobacter amylophilum. It is a spore former, motile in young cultures, and produces active destruction of potato with gas formation. It is active in the fermentation of starch as well as pectin. Orla-Jensen (1919) in a scheme of classification has designated Pectobacillus as a genus for the clostridial and plectridial species of bacteria capable of fermenting pectin. Düggeli (1921) studied the prevalence of pectin-fermenting bacteria in the soil. In a table containing the results of this study included in Waksman's (1927) "Principles of Soil Microbiology," is given the number of bacteria as determined in different types of soil. Deciduous forest and marsh land soil show the lowest number of pectin-decomposing bacteria, while the largest number may be found in

garden soil and in coniferous forest soil. Kluyver and Donker (1926) in a treatise on the fermentative processes of certain facultative anaerobic bacteria, refer to the use of lemon pectin. This pectin was reported as pure and was used as a 2% solution. Their strains 11 and 13 gave a distinct fermentation on this pectin medium. As the result all alcohol precipitatable material was fermented. Coles (1926) employed a lemon pectin in an attempt to develop a differential medium for the colon-typhoid group of bacteria. In this study a number of strains of Bacterium coli, Bact, aerogenes, Bact. oxytocum, Bact. cloacae, Bact. viscosum-aerogenes, and Bacillus acelo-ethylicus were used. He found that pectin was fermented with the production of acid and gas by 7 out of 13 strains of Bact. oxytocum, 4 of 9 strains of Bact, aerogenes, 2 strains of Bact, viscosum-aerogenes, and by 2 strains of Bacillus aceto-ethylicum. No description was given of the pectin used. Weyer and Rettger (1927) in an extensive study of butyl alcohol and acetone-producing bacteria, designate the different strains of Clostridium aceto-butylicum as pectin-fermenting bacteria. No mention was made of the source of the pectin employed for this study.

The investigations having to do with pectin and its fermentation by micro-organisms have been conducted under such varied conditions as largely to prevent a comparison of the results. In many cases naturally occurring pectin was employed, which has been secured from different plants. The usual custom was to use plant tissue. In many reports no mention is made of the kind or character of the pectin used. As a result, there is much confusion in the literature regarding the question of retting, and the organisms responsible for this process. Furthermore, there has not been a clear understanding of the organisms causing soft rots of vegetables and as a result no adequate scheme for the classification of these organisms has been provided. Our knowledge concerning the pectin fermenting bacteria is limited and fragmentary.

EXPERIMENTAL

This study had for its purpose the isolation and study of organisms capable of fermenting pectin. The organisms were isolated from several different sources. It was hoped to gain a fair idea of the occurrence of pectin-fermenting bacteria in nature. A study of certain organisms which have been found to ferment pectin by other investigators was also undertaken.

METHODS FOR THE ISOLATION AND STUDY OF BACTERIA FERMENTING PECTIN.

This part of the work consisted in the isolation of organisms for many different sources, and of a study of their morphology, their cultural characteristics and their fermentation reactions on many different sugars, alcohols, and poly-saccharides, including pectin.

Methods and technique. The pectin used was supplied by the California Fruit Growers' Exchange. It is a very fine, nearly white powder. It forms an opalescent solution in water, and exhibits colloidal properties. An attempt to filter the solution through an Empire bacteriological filter by suction was abandoned as filtration occurred very slowly. The specific

rotation was (a) = $+185.5^{\circ}$ at 30° C. This reading was obtained from a 0.5% pectin solution in water. The cylinder used in the examination of the solution was 10 cm. long. The pectin solution contained no reducing

substances when tested with Fehling's solution.

In a communication from Dr. C. P. Wilson, Director of the research laboratories of the California Fruit Growers' Exchange, the method of preparation is given as follows: "The pectin sent you was prepared in accordance with U. S. Patent No. 1,497,884. The method of preparation is briefly as follows: Chopped lemon peel from which citric acid has been removed is extracted with a 0.5% solution of sulphurous acid for about an hour at 90° C. The acid solution containing the pectin is drawn off and cooled and the pectin precipitated by means of aluminum hydroxide, which is formed in the solution by adding in rapid succession and with violent agitation sufficient NH₄OII and Al₂(SO₄)₃ to precipitate the pectin. The amounts of reagents are determined by laboratory tests.

"The precipitated pectin is drained of its mother liquor, washed with water, dried and ground. The dry powdered product is suspended in strong alcohol containing enough HCl to convert the aluminum hydroxide present into aluminum chloride, which being soluble in alcohol is removed when the latter is drawn off. After further washing with neutral alcohol the product is dried, when it is reground and is then ready for use. The ash content of the finished pectin is from about 1.5 to 3%, most of which

is probably Al₂O₂.

"The product which you have been using was made in accordance with the above method and from the many statements made to us by practical users as well as by persons doing research work on pectin, it appears that this is the purest pectin which has become available commercially."

These facts concerning the properties and preparation of pectin seem to warrant its use as a dependable substrate. The medium commonly employed consisted of 0.3% pectin, 0.2% K_2HPO_4 , and 0.2% NH_4Cl in water. It was adjusted to pH 7.0-7.2, tubed in Durham tubes, and sterilized in the autoclave at 121° C. for 15 minutes. Pectin agar consisted of the same constituents with an addition of 1.5% agar. Since the pectin medium contains no reducing substances or other fermentable material other than

pectin, any fermentation must be due to the pectin itself.

The first method of procedure was to inoculate a tube of the medium with any substance suspected of containing pectin fermenters, if fermentation occurred, then a transfer was made from this tube to a second tube and frequently to a third tube before the fermenting material was finally plated out for the isolation. Later work indicated that whenever fermentation occurred in the first tube, it could be plated and the organisms isolated without enrichment. The fermenting mixture was plated on pectin agar. The colonies that grew were cultured and again inoculated into pectin Durham tubes. In case fermentation (acid and gas formation) occurred, the fermenting mixture was plated on glucose-phosphate agar to detect any possible contamination. Whenever a mixture was present in the last plating, the cultured colonies were again returned to the pectin medium and replated. In no case was any organism recorded as a pectin fermenter unless it produced both acid and gas from pectin.

The organisms studied were isolated from the following sources: A soil preparation, creek water, decayed potatoes and parsnips, cornstalks,

insect contamination, hay infusions, and sewage. The prepared soil consisted of a mixture of garden, cornfield and residual forest soils with a frequent application of ground cornstalks. This mixture of soil was treated from time to time with phosphate, lime and ammonium salts. It was kept in good tilth by frequent cultivations and by preserving an optimum moisture content. This soil was an important source of organisms throughout the work. A further study of different sources revealed that pectin-fermenting bacteria were present in practically all decayed material as well as in certain spoiled canned vegetables. The canned vegetables studied consisted of tomatoes, Swiss chard, peas, beans, spinach, asparagus, and pumpkin. It was an interesting observation that wherever pectin-fermenting organisms were found in canned material the vegetable contents showed a softened condition and frequently the production of gas.

The preparation of the different media containing sugars, polysaccharides, alcohols, and glucosides was carried out with the utmost care. Each medium in addition to the carbohydrate to be studied consisted of 1% peptone, 0.2% K., HPO., and Andrade indicator. The carbohydrate was used in concentrations ranging from 0.3% to 0.5%. The solutions were adjusted to pH 7.0, tubed in Durham tubes, and sterilized in the autoclave at 121° C. for 12-15 minutes. This method of sterilization was saitsfactory in most cases since the tubes were rapidly cooled after leaving the autoclave. different solutions were tested by means of bacteria of known fermentative powers to determine whether the sugars had been broken down by sterilization. In only a few cases was there any indication of such a change. In later work the carbohydrate was sterilized separately and added to the medium under sterile conditions. To facilitate this a 2% solution was sterilized and added in correct amount by means of a sterile pipette to the Durham tubes containing the basic medium. Ample incubation was allowed before inoculation in order to eliminate any contaminated tubes and to permit dispersion of the carbohydrate.

Indol production was determined by growing the cultures in tryptophane broth for 3-5 days. The Ehrlich test was employed. A few drops of the para-di-methyl-amino-benzaldehyde solution, prepared according to standard methods, was placed on the lower tip of the cotton stopper along with a drop or two of concentrated HCl. The cotton stopper was again placed in the tube and forced down to within 1½ inches of the liquid. The tubes were then placed in boiling water to facilitate volatilization of the indol. A distinct pink coloration of the cotton stopper indicated the presence of the indol. The tubes were always boiled, but observation showed this was unnecessary with most of the cultures since sufficient indol had collected in the cotton stopper to produce the pink condition as soon as the

reagents were added.

Proteolysis of gelatin was determined by means of the Frazier (1926) test. This consisted in growing a giant colony in the center of a Petri dish on medium containing phosphates (0.1%) and gelatin (0.1%) in addition to 1.5% agar and 0.1% peptone. The test was carried out by the use of two such plates. After several days' growth, one plate was flooded with 1% tannic acid solution and the other plate was flooded with acidified 0.2% mercuric chloride solution. Tannic acid solution precipitates the proteoses, but has no effect on amino acids or simpler nitrogen compounds. In case of porteolysis, a clear zone surrounds the colony and beyond this is a white

precipitated band. Where there is no proteolysis the plate is of uniformly white appearance. The mercuric chloride solution precipitates the proteins, but has no effect on peptones, proteoses, or simple nitrogen compounds. A plate showing proteolysis when flooded with the acidified HgCl shows a clear zone about the colony. The remainder of the plate wheer the proteolytic enzymes had not reached appears opaque white. The ordinary gelatin liquefaction tube method was used as a control on the

cultures which gave a positive proteolysis test.

The organisms were also grown on sterile slices of Irish potatoes, sweet potatoes, carrots, parsnips, and apples. This study was carried out on the assumption that pectin fermenting bacteria would soften such vegetables. The vegetables were prepared in the following manner. Large specimens were thoroughly washed in water and then in a 60% alcohol solution. The top and bottom sides, which would come in contact with the cutting apparatus, were sliced off by means of a sterilized scalpel. Cylinders were now cut out by means of sterilized apple borer and dropped into a pan of sterile boiling water. After a few seconds they were removed, cut to form a slanting surface and introduced into sterilized potato tubes. The tubes were immediately placed in an Arnold sterilizer and heated at 75° C. for one hour. This sterilizing procedure was used on the two following days. Sufficient incubation was allowed to insure the use of sterile vegetables.

It has been commonly reported that pectin fermenters are usually active starch digesters. Consequently, additional study was made of this character, besides the use of "soluble starch" in the Durham fermentation tubes. Starch agar was prepared by adding a sterilized solution of starch to a bottle of melted nutrient agar so as to make a medium of 0.2% starch. The agar was poured into plates and allowed to solidify. In this manner starch agar plates were prepared with both "soluble starch" and commercial corn starch. The culture was streaked over the plates, following the technique used by Allen (1918). After two days incubation at 37° C. the plates were flooded with a saturated iodine solution in 50% alcohol. Diastatic action was indicated by a wide uncolored area about the colonies.

Pectin-fermenting bacteria have been considered significant because of their ability to ret flax and hemp. Since this investigation was carried out in connection with studies on the fermentation of cornstalks it was important to know whether these pectin-fermenting bacteria would ret cornstalks. The latter were cut in slices by means of a sharp knife. These slices were sterilized in the autoclave at 121° C. for an hour. After sterilization a nutrient solution was added containing 0.1% K₂HPO₄, 0.1% NH₄Cl, and 0.2% pectin. The tubes of these sliced cornstalks were then

inoculated with the culture to be tested.

The production of acetyl-methyl-carbinol was determined for all of the organisms studied by making a qualitative test of certain of the sugar fermentation cultures. The cultures employed were those growing on glucose, sucrose, mannitol and salicin broth medium. The test was made after fermentation had proceeded for 36 to 48 hours by adding 10% KOH in amount equal to the volume of the culture. It was then gently agitated and incubated at 37° C. Observations were made after three, twelve and twenty-four hours. Motility tests were made from 18 to 24 hours old broth cultures by the hanging drop method. These results were checked by means of stab cultures in semi-solid agar. Capsule formation was

studied from 24 hour old cultures in litmus milk. Capsule formation was determined by Welch's glacial acctic acid method.

The non-sporebearing pectin-fermenting bacteria showed a very close resemblance to certain species of the genera *Escherichia* and *Aerobacter* and therefore some study was made with reference to their sanitary significance. This study was made by streaking the cultures on plates of Endo and Eosin-methylene-blue media. The colonies of these organisms were compared to the colonies of *Escherichia coli* and *Aerabacter aerogenes* under the same conditions after both a two and a four day incubation period.

GENERAL CHARACTERISTICS OF THE PECTIN-FERMENTING BACTERIA

The pectin-fermenting organisms isolated were found to be included

in the genera Aerobacter, Bacillus, and Clostridium.

The organisms fermenting pectin belonging to the genus Aerobacter are rather small gram negative rods without spores, frequently showing bipolar staining and manifesting exceptional ability in the fermentation of a large number of sugars, polysaccharides, alcohols, and glucosides. They are further characterized by rarely exhibiting any protolytic action and by the production of acid and gas in litmus milk without any curd formation. These organisms are usually very strong indol and acetyl-methyl-carbinol producers. They agree with the characteristics of the genus Aerobacter in ability to oxidize the acids formed from many of the sugars, and consequently are methyl-red negative. But unlike many of the genus Aerobacter they are very active pectin fermenters, producing acid and gas and showing the ability to soften vegetable tissue.

The sporulating aerobic pectin-fermenters are very similar to Bacillus aceto-ethylicum. They are gram negative, very long, thin rods. They are motile but unlike B. aceto-ethylicum they liquefy gelatin. They are likewise similar to this organism in producing the same characteristic slow growth on all artificial media. However, they are very active fermenters, producing acid and gas from all sugars, polysaccharides, and glucosides employed, but fail to ferment a few of the polyatomic alcohols. Litmus milk is fermented with acid and gas production. Pectin is also fermented with the formation of acid and gas. Pentosan prepared from cornstalks was also fermented with acid and gas production. Potatoes, carrots, and apples are rapidly macerated by this group of organisms. As a result of this maceration all of the tissue is destroyed with the exception of the tracheal tubes. Indol and acetyl-methyl-carbinol are not produced. These organisms in addition show the ability to ret cornstalks slowly, so that the fibrous parts are easily separated from the pith.

The group of anaerobic pectin fermenters includes a large number, many of which seem to be better classified as micro-aerophiles than as true anaerobes. These organisms are generally gram positive, motile, and form spores, but they rarely appear as true clostridia. They are active fermenters, but rarely attack the alcohols. The colony is compact and of light brownish color. Usually there is no (or very slow) liquefaction of gelatin Pectin is fermented with the formation of acid and gas. Some cultures are also active pentosan fermenters. These organisms also soften vege-

tables, especially potatoes and carrots,

STUDIES ON THE PECTIN FERMENTING BACTERIA BELONGING TO THE GENUS AEROBACTER

The results of the detailed study of these organisms are given in Table I.

These results show the close relationship existing between many aerobic non-sporeforming pectin-fermenting bacteria obtained from a variety of sources. These organisms are characterized by many of the same features reported for the spore-forming, pectin-fermenting bacteria by previous investigators. Proteolysis is absent or very slow; there is active fermentation of many carbohydrates, including pentose sugars and starch; the production of a softened condition in vegetable tissue is a characteristic of most of these organisms. Another character possessed by these organisms is the ability to oxidize the acids formed. In certain of the sugars and alcohols, such as levulose, mannose, galactose, xylose, arabinose, dulcitol, and sorbitol, the organisms rapidly reduce the acidity. In other carbohydrates this characteristic is variable. With glycerol, mannitol, adonitol, trehalose, sucrose, and lactose utilization of the acids formed is very rare. A study of the ability to reverse the reaction often was an aid to the classification of the organisms.

The production of both indol and acetyl-methyl-carbinol is a prominent characteristic. This is true for all but a very few of the forms isolated. A few organisms produce acetyl-methyl-carbinol without the formation of indol.

The fermentation of pectin was of such a nature as to destroy all of the alcohol precipitable material. In addition to the formation of acid and gas, all of the cultures produced reducing substances when tested by Fehling's solution.

None of the organisms of this group was able to ret cornstalks.

LEGEND FOR TABLE I

M - Mannitol

s.r = Short rod + = Positive reaction - = Negative reaction 1 2 3, 4 = Proportional reaction +r = Acidity followed by reduction SI. = Slight s = Slow ? - Questionable * = Ring \$ = Sediment Pel. = Pellicle F = Flaky L. Brown = Light brown D. Green = Dark green A = Acid G == GasS = Softened R = Reduction C == Curd Cl = Cloudy G1 = Glucose Su = Sucrose Sa = Salicin

TABLE I. CULTURAL CHARACTERISTICS OF PECTIN-FERMENTING BACTERIA OF THE GENUS AEROBACTER.

Cult- ture	Shape	Size	in μ	Arrange - ment	Gram Reac- tion	Gra	Granules	
No.		Wide	Long			Iodine	M.B.	i
1	s.r	0.8-1	1.2-4.5	Single	-	+	+	1
2	s.r	0.8-1	0.8-4.5	Single	10-10-70	+		2
3	s.r	0.8-1.0	1.5-3.8	Single		+	+	1
4	s.r	0.6-0.8	2.0-4.5	Single	-	+-	+	2
5	s.r	0.8-1	1.5-3.0	Single	- Common	+ ?		1
6	s.r	0.8-1.2	1.2-3.5	Single		9	_	1 2
7	s.r	1.0-1.2	1.5-5.0	Single	0.000.000	+	+	3
8	s.r	1.0-1.2	1.5-3.5	Single	disco	+	-	3
9	S.T	1.0-1.2	1.5-4.0	Single	2000	+ + ?	describe	3
10	s.r	1.0-1.2	2.0-4.5	Single	garage	+	+	3 2 1 2 2 2 2 2
11	s.r	1.0-1.2	0.8-3.0	Single	and the same of th	?		1
12	s.r	1.0-1.5	1.5-3.0	Single	-	+	+	2
13	s.r	0.8-1.0	2.0-5.0	Single		+ +	++	2
14	s.r	1.0-1.2	1.5-3.0	Single	-	+	-	2
15	s.r	1.0-1.2	2.0-5.0	Single	garange	+	-	2
16	s.r	1.0-1.2	1.7-2.5	Single	-	+		2
				Single				
17	s.r	0.6-0.8	0.8-2.0	Chain	- Andrews			2
				Single				
18	s.r	0.6-0.8	1.5-3.5	Chain		+		1
20	s.r	0.7-1.0	2.0-4.5	Single		+		3
21	s.r	1.0-1.2	2.0-5.0	Single		+	+	3
22	s.r	0.9-1.0	2.5-4.5	Single	annes.	+	++	3
				Single				
23	s.r	0.6-0.8	0.8-2.0	Chain		+		1
				Single				
24	s.r	1.0-1.2	1.5-3.0	Chain	Gardane	+	+	1
				Single				
25	s.r	0.3-0.5	0.4-1.5	Chain		+		1
26	s.r	0.7-1.0	1.6-2.0	Single	servicesys	+ + +	+	2
27	s.r	1.0-1.2	1.8-3.0	Single	—	+	++++	2
28	s.r	0.8-1.0	1.5-3.5	Single		+	+	1
29	s.r	0.8-1.0	1.5-3.5	Single			+	1
30	s.r	0.6-0.8	0.8-2.0	Single	_			2
31	s.r	0.8-1.0	0.8-3.0	Single	Warrante		+	2
32	s.r	1.0-1.2	2.0-4.5	Single	national .			2
33	s.r	0.9-1.2	1.5-3.0	Single			+	1 2 2 2 1 2
34	s.r	0.8-1.0	1.5-3.0	Single	-		+	
35	s.r	0.8-1.0	1.5-3.0	Single	-			3
36	s.r	0.6-0.8	1.0-3.0	Single				-
37	s.r	0.6-0.8	1.0-1.2	Single			-	-
38	s.r	0.8-1.0	1.0-2.5	Single	6 00.00*	2		2
39	s.r	0.6-1.0	1.2-3.0	Single		2	+	2

TABLE I-(Continued)

Cul- ture	Spores	Motil- ity	Indol		Acetyl- Carl	Methyl binol	•	Nitrate reduc- tions	Uric Acid	M.R. re-
No.				Gl	Su	M	Sa		1	action
1			+	+++++++++	+	1		+	3	
2 3	_	drastron	+	+	++	_	+	+	3	
	1 1	-	+	+	+	+	+	+	3	
4 5		*****	+	+		++?		+++++++++++++++++++++++++++++++++++++++	3	
. 6			+ +	+	++++	1	?	+	2	-
7		and the same of th		I	+		7	+	2 3	
8	1 _		1	-T-		?	1 -	1	3	-
9			+	+	+		4	+++++++++++++++++++++++++++++++++++++++	3	
10	i		+	+	+	_	+ - ?	1	3	
11	l i		+	+	+	+ ? ?	manau	-	3	William St.
12	-		+	+	+	?	?	+	3	
13	-		+	+	+	?	?	+	3	
14	-	*****	+	+	+	1	_	+	2	_
15		+ + + + + + + + + + + + + + + + + + + +	+	+	+	Marine di		+	3	
16 17	_		+ '	+	+		+ + sl	+	3	Brend's
18		+					+	+	1	
20	_		-	7	+		+	+	2	
21			T	+	+	-	81	+	3	
22				I		++++		+	2 3	
23		4.		H	I			T	3	
24			+ 1	+		T	_		3	
25		+ 1	1	+	+			H	3	
26			+	+	+	+			3	_
27	-		+	+	+	?	7	+	3	
28	_		+	+	+	++???	? ? ?	+	3	
29		******	+	+	+	?	?	+ + + +	3	
30			+	+	+	+	_	+	2	
31			+++++++++	+++++++ ++++++++++++++++++++++++++++++	+	++		+	2	
32 33	_	-	+	+	+	*****	?	+ +	3	
34	_	-	+	+	++++++++ ++++++++++++++++++++++++++		? + +	+	3	
35			+	+	+		+	+	3	
36		1	+	+	+ +		*****	+	2	_
37		+		+	+			+	2 3	-
38		-	4	I		?			2	
39		-	+	T	+	-		+	2	

TABLE I—(Continued)

Cul- ture	H ₂ S	Pro- teo- lysis	Ska- tol	Source	Broth		Litmu	s Milk		Dias- tase
No				* 1		A	G	R	C	İ
1	1		-	Insect	Cloudy	+		1		1 +
2	1	-	-	Rotted pot.	Cloudy	+			_	-
3	1	S		Rotted pot.	Cloudy§	+		{		-
4	2	mateur	_	Hay infus.	F. Pel.§	+	1 - 1		-	
5	2			Mixed cult.	Cloudy	+	+] —
6	2	8	+	Mixed cult.	Cloudy	+	+		*****	+
7	1	#*************************************	Billiotena	Spec. soil	Cloudy	+	+	-		_
8	1		_	Spec. soil	Cloudy	+	+		_	+
9	1		inn	Spec. soil	Cloudy		+++	Ampun	-	-
10	3	tutuse		Spec. soil	Cloudy	+	+			+
11	4			Spec. soil	Cloudy	+	+	-	_	-
12	2	_		Creek water	Cloudy	+	+	E774-10	antere	+
13	2			Creek water	Cloudy	+	+		-	+
14	1			Creek water	Cloudy	+	******	-	-	+
15	1		+	Creek water	Cloudy	+	+	attend		Service .
16	1	_	-	Creek water	Cloudy	+	+ +	_	-	+
17	1	-	teamor	Creek water	Cl. Pel.	+	+		-	
18	1			Creek water	Cl. Pel.	+	+	+		-
20	1			Creek water	Cloudy*	+	+++		Miles and Miles	+
21	2	8	?	Creek water	Cloudy	+	+		amme	Majora
22	1	8		Creek water	Cloudy	+	+	-		
23	2		+	Rotted pot.	Cloudy*	+		+	+	_
24	2		+	Rotted pot.	Pel.	+	++			+
25	2	8		Rotted pot.	Cloudy*	+	+	+	+	-
26	1		+	Mixed cult.	Cloudy	+	+	-	*******	
27	2		+	Mixed cult.	Cloudy	+	+	- Andrews	-	
28 29	2	_		Creek water	Cloudy	+	+	S	-	+
30	1			Creek water	Cloudy	+	+	8		+
31	1	-	+	Hay infus.	Cloudy§	+	+++++		+	991000
32	1		+	Hay infus. Creek water	Cloudy§	+	+	-	+	_
33	3	B-von.	+		Cloudy	++	1 +		+	1 +
34	?		+	Creek water Hay infus.	Cloudy*	+	1 + 1	8	+	+
35	9			Hay infus.	Cloudy Cloudy	+	+		+	-
36	2	3		Rotted pot.	Cloudy*	+	+	11-1-1	+	
37	1	++		Rotted pot.	Cloudy*	+		water	+	+
38	1	<u> </u>		Hay infus.	Cloudy*	+	+		+	-
39	2		+	Creek water	Cloudy	+	+ +	Advento.	+	-
03				Oreen water	Cloudy		1			1

TABLE I—(Continued)

Cul-	1				1		T		1		1		1	
ture	Glu	cose	Levi	ulose	Man	nose	Gala	ctose	Mal	tose	Suc	rose	Lac	tose
No.	A	G	A	G	A	G	A	G	A	G	A	G	A	G
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 20 21 22 23 24 25 26 27 28 29 30 31 32 33 33 34 35 36 37 38 38 38 38 38 38 38 38 38 38 38 38 38	+++++++++++++++++++++++++++++++++++++++	+++++++++++++++++++++++++++++++++++++++	+r +r +r +r +r ++ ++ +r +r +r +r +r +r +	+++++++++++++++++++++++++++++++++++++++	+r +r +r +r +r +r +r +r +r +r +r +r +r +	+++++++++++++++++++++++++++++++++++++++	+r +r +r +r +r +r +r +r +r +r +r +r +r +	+++++++++++++++++++++++++++++++++++++++	++++++++++++++++++++++++++++++++++++++	+++++++++++++++++++++++++++++++++++++++	++++++++++++++++++++++++++++++++++++++	+++++++++++++++++++++++++++++++++++++++	++++++++++++++++++++++++++++++++++++++	+++++++++++++++++++++++++++++++++++++++

TABLE I-(Continued)

Cul-	Ra		Rha			ha-		ezi-	Sa			yg-		scu-	371	
tu e	no		no			se	to		ci			lin		in	Xyl	
No.	A	G	A	G		G	A	G	A	G	A	G				G
No. 1 2 3 4 5 6 6 7 8 9 10 11 12 13 14 15 16 17 18 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 37 37 37 37 37 37	A ++++++++++++++++++++++++++++++++++++	80 0 +++++++++++++++ ++++++++++++++++	A +?+++++++++++++++++++++++++++++++++++	G + ? - + + ? ? ? ? ? ? ? + + ? - + + + +	A ++++++++++++++++++++++++++++++++++++	G ++++++++++++++++++++++++++++++++++++	+r +r +r +r +r +r +r	G	A ++++++++++++++++++++++++++++++++++++	4 +++++++++++++++++++++++++++++++++++++	A	? ?	A ++++++++++++++++++++++++++++++++++++	C ++++++++++++++++++++++++++++++++++++	A + r + + + + + + + + + + + + + + + + +	G + + + + + + + + + + + + + + + + + + +

TABLE I—(Continued)

Cul- ture	Arabi-		ly- erol		nni- tol		ilci- ol		rbi- ol		oni- ol		osi- ol		yth- tol
No.	A G	A	G	A	G	A	G	A	G	A	G	A	G	A	G
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 38 38 38 38 38 38 38 38 38 38 38 38	+r + + + + + + + + + + + + + + + + + +	+++++++++++++++++++++++++++++++++++++++	+++++++++++++++++++++++++++++++++++++++	+++++++++++++++++++++++++++++++++++++++	+++++++++++++++++++++++++++++++++++++++	+r 	+ + + + + + + + + + + + + + + + + + + + + + + + + + + + +	+r +r +r +r +r +r +r +r +r +r +r +r +r +	++++++++++++++++++++++++++++++++++++++	++++++++++++++++++++++++++++++++++++++	+++=++++++++++++ +++++++++++++++ ++	++++++++++++++++++++++++++++++++++++++	++++++++	+	?

TABLE I-(Continued)

Cul-	Gly	7CO-	D	ex-		ol.	In		Pe	ec-	Pe	nto-	L	ig-	Ce	llu-
ture	ge		tr	in		rch	li			in		an		in		ose
No.	A	G	A	G	A	G	A	G	A	G	A	G	A	G	A	G
1	+r	+	+r	+	+r	+	$+\mathbf{r}$	+	1+	+	+			-		0000
2	+	+			$+\mathbf{r}$	+			$+\mathbf{r}$	+			-			
3	+r	+			+	+			+r	+	rat-60					
4	+r	+			+	+			+r	+						
5	+r	+	+r	+	+r	+	+r	+	+	+	-	_				
6	+r	+	+r	+	+r	+	+	+	+	+	-		1000	moditions		
7	+	+	?	_	+	+		-	+r	+			1	minutes.		
8	+r	+		_	+r	+			+r	+	-	-	15			
10	+r +	+		-	+r	++		_	+r +r	+			7	1000-00-		
11	+r	++			++	+	_		+r	++			1			
12	+r	+.	+r	+	+r	+	+r	+	+r	+		antition and				
13	+r	+	+1	+	+r	+	+r	+	+r	+	_	-	1 2 7		1	
14	+r	+	+r	+	+r	+	+	+	+r	+	_		,			
15	+r	+	+	+	+	+	+r	+	+r	+						
16	+r	+	+1	+	+r	+	+	+	+r	+						
17		11000						_	$+\mathbf{r}$	+		_	100	green an		derivate
18	+r	sl				Marketon.	-		$+\mathbf{r}$	+	-	-	and a	~	-	-
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Growth on litmus milk showed the production of acid and gas. A few of the cultures reduced the litmus and several caused the formation of a curd.

The softening of vegetables and fruits was studied to some extent. Sweet potatoes failed to show a change as a result of the growth of these organisms. In a few cases gas was produced on apple, but no maceration resulted. The softening of parsnips was less marked than that of potatoes and carrots. The softened condition was the result of a loosening or falling apart of the plant tissue with rarely any destruction of the cell structure. Discoloration of potatoes and carrots was common.

THE CLASSIFICATION OF THE PECTIN-FERMENTING BACTERIA OF THE GENUS AEROBACTER

In general, it is probably unwise to use the fermentation of a single sugar or any other single character as a sole basis of specific differentiation. A careful correlation of characters of a dependable nature should be used in place of one or more unrelated differences. The production of indol and acetyl-methyl-carbinol, the liquefaction of gelatin, the use of litmus milk, and the fermentation of many chemically pure sugars have been so standardized as to form reliable bases for the classification of bacteria. The use of pectin as well as other purified natural products should be considered only as an aid to bacterial classification at present. A highly purified pectin may be of value in the future for classifying bacteria when the chemistry and the fermentation of pectin by microorganisms are better understood.

These organisms were found to fall within the genus Aerobacter as defined by Weldin (1927). This generic diagnosis is given as follows: "Motile or non-motile, non-sporeforming rods, fermenting both glucose and lactose with both acid and gas. Produce acetyl-methyl-carbinol (Voges-Proskauer reaction positive); reverse the reaction of 0.5 percent glucose-phosphate-peptone solution relatively rapidly; generally able to utilize uric acid as an available source of nitrogen. Pathogenicity usually slight or absent."

A study of the members of this genus which were isolated showed them in general to be most closely allied to the three species Aerobacter cloacae, A. aerogenes, and A. oxytocum. Few only of the forms isolated agree sufficiently with these species to be included with them, the remainder are described as new species. In order to create these new species, other differential characters have been employed in addition to those included in the specific diagnosis by Weldin. It is now necessary to modify the specific diagnoses for A. cloacae, aerogenes and oxyticum from that given by Weldin in order to differentiate the new from the original species. The modifications suggested are justified by the experimental data at hand.

A careful evaluation and correlation was made of the characters used for classification. It was considered best to establish a new species on not less than two distinct characters. Two cultures differing in one fundamental character or in several minor characters were considered as the same species unless a correlation of characters was not possible. The characters were evaluated on the basis of the purity of the substrate used, the constancy of the results obtained, and on the previous usage of the character in classification.

A key to the organisms has been prepared, using such differential characters as the fermentation of glycerol, dulcitol, aesculin, melezitose, and raffinose and the production of diastase and indol and is outlined below.

Key to the pectin-fermenting bacteria of the genus Aerobacter:

a. Acid and gas from glycerol. Non-motile. b. Acid and gas from dulcitol. c. Acid and gas from melezitose (Nos. 35, 38)Aerobacter faeni 2c. Neither acid nor gas from melezitose (1, 6, 12, 13, 14, 16, 20, 28, 29, 32, 33, 5, 22, 26, 27, 15, 21, 39)
2b. Neither acid nor gas from dulcitol. c. Acid and gas from melezitose. d. Acid and gas from galactose (7, 9, 10, 11)
2d. Neither acid nor gas from galactose (8)
2c. Neither acid nor gas from melezitose. d. Indol not produced (34)Aerobacter aerogenes
2d. Indol produced (2, 3, 4, 24, 30, 31)Aerobacter decolorans
2a. Neither acid nor gas from glycerol. Motile. b. Acid and gas from dulcitol. c. Indol produced (23)
2c. Indol not produced (25)Aerobacter motorium
2b. Neither acid nor gas from dulcitol. c. Acid and gas from aesculin (18)Aerobacter mitificans
2c. Neither acid nor gas from aesculin. d. Acid and gas from raffinose (36, 37)
2d. Neither acid nor gas from raffinose (17)

The primary groupings of the organisms were made on the basis of glycerol fermentation. This characteristic is correlated with motility and corresponds to the divisions made in previous classifications of the genus Aerobacter.

The organisms which were unable to ferment glycerol with the production of acid and gas were in agreement with the diagnosis given by Weldin (1927) for Aerobacter cloacae. Weldin's diagnosis is as follows:

"Motile rods, 0.5 to 1.0μ broad by 0.8 to 2.0μ long, conforming to the generic diagnosis. Sucrose is fermented with acid and gas production; glycerol, starch, dulcitol and inositol are rarely attacked and adonitol is not fermented. Gelatin is usually liquefied. Indol is usually produced. Litmus milk is acidified and coagulated. Originally isolated from sewage. Found in the alimentary tract."

In order to subdivide the group, the early descriptions were used. That of Jordan (1890) was brief, but was later confirmed and extended by Castellani and Chalmers (1920). As far as comparison was possible it was found that the later description of Aerobucter cloacae differed from the isolated group of non-glycerol fermenters in general by the fermentation of dextrin, the failure to ferment salicin, and by the production of indol. These were the differential characters which justified the formation of a new species for cultures 36 and 37.

Cultures 17 and 18 differed from Aerobacter cloacae, in addition to the characters mentioned above for the group, by their failure to liquefy gelatin and to ferment raffinose. Also, culture 17 differed from 18 by the absence of a positive Voges-Proskauer reaction, by the failure to ferment assculin, and by the ability to macerate vegetables. These organisms have

been considered as two new species.

Cultures 23 and 25 also differed from Aerobacter cloacae in the same manner as did 36 and 37 and in addition were unable to liquefy gelatin, failed to ferment dextrin, and fermented aesculin and dulcitol. These cultures were differentiated by the production of indol and the fermentation of glycogen, adonitol, and inositol. They were considered as distinct species.

Aerobacter salicinovorum n. sp.

Source: Rotted potato.

Cultures 36 and 37.

Morphology: Medium: Glucose-phosphate-peptone broth. Age: Twenty-four hours. Temperature: 37° C. Form: Rods. Arrangement: Single. Limits of size: 0.6μ to 0.8μ by 1.0μ to 2.0μ . Ends: Rounded. Capsules: Absent in twenty-four hours culture of litmus milk.

Endospores: Absent.

Motility: Motile.

Staining reactions: Gram negative. No granular appearance with iodine.

Cultural characteristics:

Colony: Size 2-6 mm. in diameter, round to oval, slightly convex, light grey in color, opaque, no pigment formation on the medium.

Agar streak: Growth abundant, filiform, shiny and butyrous.

Plain broth: Cloudy, ring formation.

Litmus milk: Acid, gas and reduction with curd formation.

Natural media: (36) Softening of carrots. (37) Softening of carrots and parsnips.

Biochemical characters: Indol not formed. Acetyl-methyl-carbinol produced from glucose and sucrose. Nitrates reduced. Uses uric acid as a source of nitrogen. Methyl red reaction is negative. H₂S produced. Gelatin liquefied. (37) Diastase not produced. (36) Diastase produced.

Fermentation reactions Acid and gas from glucose, levulose, mannose, galactose, maltose, sucrose, lactose, raffinose, rhamnose, trehalose, salicin, xylose, arabinose, mannitol, sorbitol, (36) soluble starch, and pectin (slight by 37). No fermentation from melezitose, amygdalin, aesculin, glycerol, dulcitol, adonitol, inositol, erythritol, dextrin, glycogen, inulin, (37) soluble starch, pentosan, or lignin.

Growth on Endo medium ('olony: Medium in size, dark red and of uniform color, slightly convex, nearly flat, and a slightly greenish sheen. (36) Shows no sheen. Medium: Light red—no change.

Growth on eosin methylene blue medium Colony: medium in size, light purple and uniform in color, slightly raised, smooth. Medium: Unchanged.

Diagnosis: Motile rods, 0.6μ to 0.8μ by 1.0μ to 2.0μ in size, conforming to the generic diagnosis. Acid and gas produced from the hexose sugars, the disaccharides, raffinose, rhamnose, trehalose, salicin, mannitol, sorbitol, and the pentose sugars. Fermentation of pectin variable. No fermentation of melezitose, amygdalin, aseculin, glycerol, dulcitol, adonitol, inositol, erythritol, or of the poly-saccharides. Litmus milk shows acid coagulation and reduction. Indol not formed. Nitrates reduced. Gelatin liquefied. Isolated from rotted potato.

Aerobacter pseudoproteus n. sp.

Source: Creek water.

Culture 17.

Morphology: Medium: Glucose-phosphate-peptone broth. Age: Twenty-four hours. Temperature: 37° C. Form: Short rods. Arrangement: Single and chains. Limits of size: 0.8μ to 2.0μ by 0.6μ to 0.8μ . Ends: Rounded. Capsules: Present in twenty-four hour culture of litmus milk.

Endospores: Absent.

Motility: Motile.

Staining reactions: Gram negative. Granular when stained with iodine.

Cultural characters:

Colony: Size, 2-4 mm. in diameter, round, flat, semi-opaque, amorphous. Medium not browned.

Agar streak: Growth good, filiform, shiny, and butyrous.

Plain broth: Cloudy and pellicle formation.

Litmus milk: Acid and gas.

Natural media: No softening on potato, carrot, parsnip, sweet potato or apple.

Biochemical reactions: Indol not formed. Acetyl-methyl-carbinol produced from salicin. Nitrates reduced. Uses uric acid as a source of nitrogen, sparingly. Methyl red negative. Slight H₂S produced. No liquefaction of gelatin. Diastase not produced.

Fermentation reactions: Acid and gas from glucose, levulose, mannose, galactose, maltose, sucrose, lactose (slight), trehalose, salicin, xylose, arabinose, mannitol, sorbitol, and pectin. No fermentation from raffinose, rhamnose, melezitose, amygdalin, aesculin, glycerol, dulcitol, adonitol, inositol, erythritol, glycogen, dextrin, soluble starch, inulin, pentosan, lignin, or cellulose.

Growth on eosin methylene blue medium Colony: Medium in size, light purple and uniform in color, flat, smooth. Medium: Unchanged.

Growth on Endo medium Colony: Small in size, bronzy to a dark red in color, very flat, showed slight acid production. Medium: Unchanged.

Diagnosis: Motile rods, 0.8μ to 2.0μ by 0.6μ to 0.8μ in size. Gives a Voges-Proskauer negative reaction, but produces acetyl-methyl-carbinol and thus conforms to the generic diagnosis. Acid and gas produced from mono and di-saccharides, the pentose sugars, trehalose, salicin, mannitol, sorbitol, and pectin. No fermentation from raffinose, rhamnose, melezitose, amygdalin, aesculin, glycerol, dulcitol, adonitol, inositol, erythritol, or the poly-saccharides. Acid and gas from litmus milk. Indol not produced. Nitrates reduced. Gelatin not liquefied. Isolated from creek water.

Aerobacter mitificans n. sp.

Source: Creek water.

Culture 18.

Morphology: Medium: Glucose-phosphate-peptone broth. Age: Twenty-four hours. Temperature: 37° C. Form: Short rods. Arrangement: Single and chains. Limits of size, 1.5μ to 3.5μ by 0.6μ by 0.8μ . Ends: Rounded. Capsules: Present in twenty-four hour culture of litmus milk.

Endospores: Absent.

Motility: Motile.

Staining reactions: Gram negative. Granular with iodine.

Cultural characters: Colony: Size, 24 mm. in diameter, round, slightly convex, opaque, shiny amorphous. Medium: Not browned.

Agar streak: Growth abundant, filiform, shiny and butyrous.

Plain broth: Cloudy, with pellicle formation.

Litmus milk: Acid, gas and reduced.

Natural media: Potato, carrot and parsnip softened.

Biochemical reactions: Indol not formed. Acetyl-methyl-carbinol produced from glucose, sucrose, and salicin. Nitrates reduced. Uses uric acid as a source of nitrogen. Methyl red negative. H₂S questionable. No liquefaction of gelatin. Pellicle formed on broth, sediment. Diastase not produced.

Fermentation reactions: Acid and gas from glucose, levulose, mannose, galactose, maltose, sucrose, lactose (slight), trehalose, salicin, aesculin,

xylose, arabinose, mannitol, sorbitol, glycogen and pectin. No fermentation from rhamnose, melezitose, amygdalin, glycerol, dulcitol, adonitol, inositol, erythritol, dextrin, soluble starch, inulin, pentosan, and cellulose.

Growth on Endo medium: Colony: Medium size, red, uniform in color, flat, smooth. Medium: Light pink—no change.

Growth on eosin methelyn blue medium: Colony: Very small, light red. uniform in color, convex, smooth. Medium: No change.

Diagnosis: Motile rods, 0.6μ to 0.8μ by 1.5μ to 3.5μ in size, conforming to the generic diagnosis. Acid and gas from the mono- and di-saccharides, the pentose sugars, trehalose, salicin, aesculin, mannitol, sorbitol, and pectin. No fermentation from raffinose, rhamnose, melezitose, amygdalin, glycerol, dulcitol, adonitol, inositol, erythritol, or the poly-saccharides. Litmus milk shows a slight reduction with the formation of acid and gas. Gelatin is not liquefied. Indol is not produced. Nitrates are reduced. Shows rapid softening of vegetables. Isolated from creek water.

Aerobacter indologenes n. sp.

Source: Rotted potato.

Culture 23.

Morphology: Medium: Glucose-phosphate broth. Age: Twenty-four hours. Temperature, 37° C. Form: Short rods. Arrangement: Single and short chains. Limits of size: 0.6μ to 0.8μ by 0.8μ to 2.0μ . Ends: Rounded. Capsules: Present in twenty-four hour cultures of litmus milk.

Endospores: Absent.

Motility: Motile.

Staining reactions: Gram negative. No granular appearance with iodine.

Cultural characters:

Colony: Size 2 mm. in diameter, rounded, raised, translucent, amorphous, and causing the browning of the medium.

Agar streak: Growth good, filiform and butyrous.

Plain broth: Ring, cloudy.

Biochemical reactions: Indol produced. Acetyl-methyl-carbinol produced from glucose and sucrose. Nitrates reduced. Uses urid acid as a source of nitrogen. Methyl red reaction, negative. H₂S produced. Gelatin not liquefied. Skatol produced. Diastase not produced.

Fermentation reactions: Acid and gas produced from glucose, levulose, mannose, galactose, maltose, sucrose, lactose, raffinose, rhamnose, trehalose, salicin, aseculin, xylose, arabinose, mannitol, dulcitol, sorbitol, adonitol, inositol, glycogen and pectin. No fermentation was produced from melezitose, amygdalin, glycerol, erythritol, dextrin, soluble starch, inulin, pentosan, lignin, and cellulose.

Litmus milk: Acid, gas and reduction with the formation of a curd.

Natural media: Slight softening of potato and carrot.

Growth on Endo medium: Colony: Small in size, dark red and uniform in color, slightly convex but very low, smooth. Medium: Light red.

Growth on eosin methylene blue medium: Colony: Medium in size, light purple and uniform in color, slightly convex.

Diagnosis: Motile rods, 0.6μ to 0.8μ by 0.8μ to 2.0μ in size, conforming to the generic diagnosis. Acid and gas produced from the common hexose sugars, the di-saccharides, raffinose, rhamnose, trehalose, and the pentose sugars. The alcohols are fermented with the exception of glycerol and erythritol. Pectin is fermented. Acid and gas is produced from many glucosides, but there is no fermentation of the poly-saccharides. Amygdalin is not fermented. Litmus milk is fermented with the production of acid, gas, a coagulation and reduction of the litmus. Indol is produced. Gelatin is not liquefied. Isolated from rotted potato.

Aerobacter motorium n. sp.

Source: Rotted potato.

Culture 25.

Morphology: Medium: Glucose-phosphate broth. Age: Twenty-four hours. Temperature: 37° C. Forms: Short rods. Arrangement: Single and chains. Limits of size, 0.3μ to 0.5μ by 0.4μ to 1.5μ . Ends: Rounded. Capsules: Present in twenty-four hour culture of litmus milk.

Endospores: Absent.

Motility: Motile.

Staining reactions: Gram negative. Granular appearance with iodine.

Cultural characters:

Colony: Size, 2-4 mm. in diameter, round, raised and slightly convex, semi-opaque, amorphous, with dense center. No pigmentation formed on the medium.

Agar streak: Growth abundant, filiform and shiny and butyrous.

Litmus milk: Acid, gas and reduction. Curd formed.

Natural media: Slight softness on carrot and potato.

Nutrient broth: Cloudy with ring.

Biochemical reactions: Indol not formed. Acetyl-methyl-carbinol produced from glucose, sucrose and mannitol. Nitrates reduced. Uses uric acid as a source of nitrogen. Methyl red negative. $\rm H_2S$ produced. Gelatin slowly liquefied. Skatol not formed. Diastase not produced.

Fermentation reactions: Acid and gas from glucose, levulose, mannose, galactose, maltose, sucrose, lactose, raffinose, rhamnose, trehalose, salicin, aesculin, xylose, arabinose, mannitol, duleitol, sorbitol, and peetin. No

fermentation was obtained from melezitose, amygdalin, glycerol, adonitol, inositol, erythritol, glycogen, dextrin, soluble starch, inulin, or pentosan.

Growth on Endo medium: Colony: Small in size, dark red and uniform in color. Slightly convex, smooth and no sheen. Medium: Red.

Growth on eosin methylene blue medium: Small, light purple and uniform in color, slightly convex, smooth. Medium: No change in color.

Diagnosis: Motile rods, 0.3μ to 0.5μ by 0.4μ to 1.5μ in size, conforming to the generic diagnosis. Acid and gas produced from the common hexose sugars, the di-saccharides, raffinose, rhamnose, trehalose, salicin, aesculin, xylose, and arabinose. The alcohols, mannitol, dulcitol, and sorbitol, are fermented, but glycerol, adonitol, inositol, and erythritol are not fermented. Pectin is fermented. No fermentation occurs from amygdalin or the polysaccharides. Indol is not produced. Gelatin is slowly liquefied. Litmus milk is fermented with the fermentation of acid, gas and a curd with reduction after 3 days. ...Isolated from rotted potato.

Aerobacter cloacae

The diagnosis for Aerobacter cloacae according to the suggested modification would be as follows: Motile rods, 0.5μ to 1.0μ broad by 0.8μ to 2.0μ long, conforming to the generic diagnosis. Acid and gas produced from sucrose, maltose, raffinose, galactose, arabinose, and mannitol. No fermentation of glycerol, dulcitol, inositol, adonitol, salicin, and inulin. Gelatin liquefied. Indol is produced. Litmus milk is acidfied and coagulated.

Orginally isolated from sewage. Found in the alimentary tract.

The non-spore forming pectin fermenting bacteria which are able to ferment glycerol may be subdivided on the basis of dulcitol fermentation. Those organisms which do not produce acid and gas from dulcitol conform quite closely to the following diagnosis given by Weldin for Aerobacter aerogenes. A non-motile rod 0.5 to 0.8 \(\mu\) broad by 1.0 to 2.0 \(\mu\) long, conforming to the generic diagnosis. Acid and gas are formed from sucrose, glycerol, inositol, adonitol, and usually from starch; dulcitol is not attacked. Gelatin is rarely liquefied. Indol is rarely formed. Litmus milk is made acid and coagulated. The organism is found in the alimentary tract of man and animals and widely distributed in nature.

The study made of these pectin fermenters revealed several distinct groups which gave well correlated characteristics. These groups were distinctly different in several ways, but according to the above diagnosis

should be considered as the single species Aerobacter aerogenes.

Earlier experimental work on Aerobacter aerogenes threw some light upon the question of its classification. One of the characters to be considered with the organisms at hand was that of the production of indol. The work of Castellani and Chalmers (1920) showed the aerogenes organism to be indol negative. However, previous work by MacConkey (1906) gave evidence to show that the organism produced indol. Later extensive studies made of organisms which were roughly considered as aerogenes by Levine and Linton (1924) and by Chen Chong Chen and Rettger (1920) showed that the majority of the organisms isolated from different sources were not able to produce indol. In cases where aerogenes was of human origin the percentages of indol positives were much less. The results of MacConkey

might be discounted since earlier tests for indol were apt to give positive rather than negative results due to the nature of the tests employed. It is suggested that Aerobacter aerogenes be considered as indol negative. It is further suggested from the results of Levine and Linton (1924) that the failure to ferment melezitose, inulin, and glycogen be considered as a part of the diagnosis for this organism. The suggested diagnosis for Aerobacter aerogenes as modified is given as follows:

A non-motile rod, 0.5 to 0.8μ by 1.0 to 2.0μ in size, conforming to the generic diagnosis. Acid and gas are produced from sucrose, maltose, glycerol, inositol, adonitol, mannitol, salicin, and aesculin; dulcitol, inulin, glycogen, and melezitose are not fermented. Gelatin is not liquefied. Indol is not formed. Litmus milk is made acid and coagulated. The organism is found in the alimentary tract of man and animals and widely distributed in nature.

The diagnosis given above is justified on the basis of previous experimental results. This diagnosis permits a better and a more detailed classification for the pectin-fermenting bacteria similar to the A. aerogenes. Culture 34 corresponds very closely to the Aerobacter aerogenes and it is to be considered thus for the present. Cultures 2, 3, 4, 30, 31, and 24 show a close correlation in characters. These cultures do not correspond to the above diagnosis for the aerogenes organism in that they produce indol. do not coagulate litmus milk, and are able to ferment glycogen. They are considered as a distinct species. Cultures 7, 9, 10, 11 differ in a few respects, but they are very closely correlated in the fermentation of melezitose and glycogen, in the formation of indol and in their growth on litmus milk. They are considered as a distinct species. Culture 8 shows several variations from that of the above group of organisms, which makes it a distinct species. This organism is V. P. negative, altho it shows a slight production of acetyl-methyl-carbinol from mannitol. It does not ferment galactose. Melezitose and glycogen are fermented and indol is produced.

Descriptions of these organisms are given as follows, with their assigned name:

Aerobacter decolorans

Culture No. 2, 3, and 24—source, rotted potato; culture No. 4, 30 and 31—Hay infusion.

Morphology: Medium: Glucose-phosphate-peptone broth. Age: Twenty-four hours. Temperature: 37° C. Form: Short rods. Arrangement: Single. Limits of size: 0.8μ to 1.2μ by 0.8μ to 5.0μ . Ends: Rounded. Capsules: Abundant in twenty-four hour culture of litmus milk.

Endospores: Absent

Motility: Non-motile.

Staining reactions: Gram negative. Granular with iodine.

Cultural characters:

Colony: Size 2-4 mm. in diameter, round, convex, and arched, opaque, amorphous, not slimy, medium pigmented.

Agar streak: Growth abundant, filiform, shiny, butyrous.

Litmus milk: Acid, or acid and gas.

Plain broth: Cloudy. Ring and sediment.

Natural media: Softening of parsnips, carrots and apple.

Biochemical reactions: Indol produced. Acetyl-methyl-carbinol produced from glucose, sucrose and salicin. Nitrates reduced. Uses uric acid as a source of nitrogen. Methyl red negative, $\rm H_2S$ produced. Gelatin not liquefied. Skatol not produced. Diastase not produced. (24) Produces diastase.

Fermentation reactions: Acid and gas from glucose, levulose, mannose, galactose, maltose, sucrose, lactose, raffinose, trehalose, salicin, aesculin, xylose, arabinose, glycerol, mannitol, adonitol, inositol, glycogen, soluble starch, and pectin. Acid is formed from rhamnose. Neither acid nor gas produced from melezitose, amygdalin, dulcitol, erythritol, dextrin, inulin, or pentosan.

Growth on Endo medium: Colony: Medium in size, uniformly red in color, slight depression in center, raised, center is darker red and no sheen. Medium: Red. No sheen.

Growth on eosin methylene blue medium: Colony: Large, brownish purple in color, raised to convex, and slimy appearance. Medium: No change.

Diagnosis: Non-motile rods, 0.6 to 1.0μ broad by 0.8 to 3.0μ long, conforming to the generic diagnosis. Acid and gas from mono- and di-saccharides, the pentose sugars, raffinose, trehalose, salicin, aesculin, many of the common alcohols, glycogen, and pectin. No fermentation from melezitose, amygdalin, dulcitol, erythritol, dextrin, inulin, and pentosan. Acid and gas in litmus milk. Indol is produced. Gelatin is not liquefied. Isolated from rotted potato and hay infusion.

Aerobacter melezitovorum n. sp.

Source: Special soil.

Cultures 7, 9, 10 and 11.

Morphology: Medium: Glucose-phosphate-peptone broth. Age: Twenty-four hours. Temperature: 37° C. Form: Rods with considerable variation in length. Arrangement: Single. Limits of size: 0.8 to 1.2μ broad by 1.0 to 3.0μ long. Ends: Rounded for (7, 9) and truncate for (10, 11). Capsules: Abundant in twenty-four hour culture of litmus milk.

Endospores: Absent.

Motility: Non-motile.

Staining reactions: Gram negative. Slight granulation with iodine.

Cultural characters:

Colony: Size 3-4 mm. in diameter, convex, opaque, radiating strands, (7) tendency to be slimy, amorphous, medium colored, a light or dark brown,

Agar streak: Growth abundant, filiform, shiny and slimy with (7).

Plain broth: Cloudy.

Litmus milk: Acid and gas. No curd.

Natural media: Slight softening of carrots and parsnips.

Biochemical reactions: Indol produced. Acetyl-methyl-carbinol produced from glucose and sucrose. Nitrates reduced. Uses uric acid as source of nitrogen. Methyl red negative. H₂S produced. Gelatin not liquefied. Skatol not produced. Diastase not produced.

Fermentation reactions: Acid and gas from glucose, levulose, mannose, galactose, maltose, sucrose, lactose, raffinose, rhamnose, trehalose, melezitose, salicin, aesculin, xylose, arabinose, glycerol, mannitol, sorbitol, adonitol, inositol, glycogen, soluble starch, and pectin. Neither acid nor gas from amygdalin, dulcitol, erythritol, dextrin, inulin, and pentosan.

Growth on Endo medium: Colony: Large, uniformly dark red, slightly raised, smooth. Medium: Red. Cultures (7 and 9). Cultures (10 and 11) Colony: Medium to small in size, of uniformly dark red color, slightly defined center, convex and smooth. Usually shows a dark green sheen. Medium: Dark red, showing a green sheen. Very similar in appearance to Es. coli.

Growth on eosin methylene blue medium: Colony: Medium in size, purplish to flesh color, slightly raised or convex, smooth, small, dark center with some reverting. Medium showed no change.

Diagnosis: Non-motile rods, 1.0μ broad and 1.0 to 3.0μ long, conforming to the generic diagnosis. Acid and gas from the mono- and di-saccharides, the pentose sugars, raffinose, rhamnose, trehalose, melezitose, salicin, asculin, all of the commonly employed alcohols except dulcitol and erythritol, glycogen, soluble starch and pectin. No fermentation from amygdalin, dextrin, inulin and pentosan. Acid and gas in litmus milk. Indol produced. Gelatin not liquefied. Isolated from a special soil mixture.

Aerobacter diversum n. sp.

Source: Special soil.

Culture 8.

Morphology: Medium: Glucose-phosphate-peptone broth. Age: Twenty-four hours. Temperature: 37° C. Form: Short rods. Arrangement: Single or pairs. Limits of size: 1.0μ to 1.2μ by 1.5μ to 3.5μ . Ends: Rounded. Capsules: Largely capsulated in twenty-four hour culture of litmus milk.

Endospores: Absent.

Motility: Non-motile.

Staining reactions: Gram negative. Granular appearance.

Cultural characters:

Colony: Size 5-8 mm. in diameter, round, slightly umbilicate, semi-opaque. finely granular, Medium not discolored.

Agar streak: Growth abundant, filiform, shiny and butyrous.

Plain broth: Cloudy, with slight ring.

Litmus milk: Acid and gas.

Natural media: Softening of potato and carrots.

Biochemical reactions: Indol produced. A slight production of acetylmethyl-carbinol only from mannitol. Nitrates reduced. Uses uric acid as source of nitrogen. Methyl red negative. H₂S produced. Gelatin not liquefied. Skatol not produced. Diastase produced.

Fermentation reactions: Acid and gas from glucose, levulose, mannose, maltose, sucrose, lactose, raffinose, rhamnose, trehalose, melezitose, salicin, aesculin, xylose, arabinose, glycerol, mannitol, sorbitol, adonitol, inositol, glycogen, soluble starch, and pectin. Acid and gas not produced from galactose, amygdalin, dulcitol, erythritol, dextrin, inulin, and pentosan.

Growth on Endo medium: Colony: Large, dark red in color, dark red cen ter, low, colony but slightly convex, shiny, reddish sheen. Medium: Red.

Growth on eosin methylene blue medium: Colony: Large, pink and uniform in color, slightly figured on surface, raised, and slimy in character. Medium: No change in color.

Diagnosis: Non-motile rods, 1.0μ broad by 1.0 to 3.0μ long, conforming to the generic diagnosis. Acid and gas produced from the mono- and disaccharides with the exception of galactose. Acid and gas produced from raffinose, rhamnose, trehalose, melezitose, salicin, aesculin, many of the common alcohols, soluble starch, and pectin. No fermentation from amygdalin, dulcitol, erythritol, dextrin, inulin, or pentosan. Acid and gas in litmus milk. Indol produced. Gelatin not liquefied. Isolated from a special mixture of soils.

The group of non-sporeforming pectin-fermenting bacteria, which ferment glycerol and dulcitol are considered to be related to Aerobacter oxytocum. The diagnosis suggested for Aerobacter oxytocum by Weldin is given as follows:

"Non-motile rods, conforming to the generic diagnosis; sucrose, dulcitol, glycerol, adonitol, and inositol fermented with the production of acid and gas. Gelatin not liquefied. Indol is usually produced. Litmus milk is acidified and coagulated. Was first isolated from milk. Found in dairy products, soil, and the alimentary tract. Is pathogenic for rabbits on intra-venous injections."

This diagnosis is based on a study of organisms referred to as oxytocus by a number of investigators. The primary characteristic used was the fermentation of dulcitol, which was in agreement by all previous investigators. The ability of the organism to produce indol, to liquefy gelatin and to ferment inulin was the source of considerable contradiction by the different investigators. Because of these discrepancies it is probable that the organisms described were different. The organism described by MacConkey (1906), which was obtained from the Kral laboratory at Vienna, may

logically be assumed to be a strain of the original organism isolated by Wyssokowitsch and it agrees with the description given by Flügge (1886) in its failure to liquefy gelatin. By considering the negative liquefaction of gelatin as a character of the original organism, a study of previous investigations show that the failure to produce indol is correlated with this character in most cases. Furthermore, the organism Bacillus oxytocus perniciosus (Kral) described by MacConkey does not produce indol. This organism is considered as the type for the species oxytocum. The species diagnosis is given as follows:

Non-motile rods, 0.6 to 0.8µ broad by 0.8 to 2.0µ long, conforming to the generic diagnosis. Acid and gas produced from sucrose, raffinose, inulin, salicin, dulcitol, glycerol, adonitol, and inositol. Melezitose and erythritol are not fermented. Gelatin is not liquefied. Indol is not porduced. Litmus milk is acidified and coagulated. Was first isolated from old milk. Found in dairy products, soil, and the alimentary tract. Is pathogenic for rabbits

on intravenous injections.

The isolated organisms showed a correlation of indol production with dulcitol fermentation, the failure to produce coagulation on litmus milk, and the fermentation of soluble starch. They do not agree in characters to the diagnosis proposed for Aerobacter oxytocum, but do correspond very closely to a number of organisms isolated and studied by MacConkey (1906). These organisms he considered as varieties of the oxytocus organ-They are widely distributed in nature, being isolated from milk, soil, decayed vegetables, and possibly from human sources. Levine and Linton (1924) showed results in which reference is made to a group of bacteria designated as group IX, which are probably the same type of organ-These studies indicate the occurrence of a group of organisms which differ from the accepted original A. oxytocum organism by the production of indol, the coagulation of litmus milk, and possibly other characters. The isolated forms prove to be capable of fermenting pectin. Cultures 1, 12, 13, 14, 16, 20, 28, 29, 32, 33, and 6, which show a positive diastase reaction. and 5, 15, 22, 26, 21, 27, and 39, which show a negative diastase reaction on starch agar, are considered as organisms in this general group and as a new species. Cultures 35 and 38 are very similar to Aerobacter melecitovorum with the exception of the added character—the fermentation of dulcitol—and are considered as a new species.

The descriptions of these organisms with their specific diagnoses are given as follows:

Aerobacter pectinovorum n. sp.

Culture	No.	So	urce
1		.Insect	
12		.Creek	water
13	• • • • • • • • • • • • • • • • • • •	.Creek	water
14	a a - a - a - a - a - a - a - a - a - a	.Creek	water
16	****	.Creek	water
20		.Creek	water
28	* D = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0 =	Creek	water
29		.Creek	water
32		.Creek	water
33	**************************************	.Creek	water
6		.Mixed	culture
5		.Mixed	culture
15		.Creek	water
22	·	.Creek	water
26		.Mixed	culture
27	# 0 M 4 0 M 0 M 0 M 0 M 0 M 0 M 0 M 0 M 0	.Mixed	culture
21		.Creek	water
39		.Creek	water

Morphology: Medium: Glucose-phosphate-peptone broth. Age: Twenty-four hours. Temperature: 37° C. Form: Short rods. Arrangement: Single and chains. Limits of size: 0.7 to 1.2μ by 1.0 to 4.0μ . Ends: (13) and (16) truncate others rounded. Capsules: Present in twenty-four hour culture of litmus milk.

Endospores: Absent.

Motility: Non-motile.

Staining reactions: Gram negative. Granules with iodine.

Cultural characters:

Colony: Size 2-3 mm. in diameter, round, opaque to semi-opaque, amorphous. No coloration on medium.

Agar streak: Growth abundant, filiform, shiny and butyrous.

Plain broth: Cloudy with ring.

Litmus milk: Acid and gas. No curd.

Natural media: Softening of potatoes, carrots and parsnips by numbers 15, 21, 32 and 29. Softening of carrots and potatoes by numbers 5, 22, 13, 26, 20, and 27. Softening of carrots by numbers 28, 39, and 14. No softening of vegetables by numbers 6, 12, 33, 16, and 1.

Biochemical reactions: Indol produced. Acetyl-methyl-carbinol from glucose and sucrose. Nitrate reduced. Uses uric acid as source of nitrogen. Methyl red negative. H_2S variable. Gelatin not liquefied. Diastase pro-

duced by numbers 1, 6, 12, 13, 14, 16, 20, 28, 29, 32, and 33. Diastase not produced by numbers 26, 22, 27, 15, 5, 21, and 39.

Fermentation reactions: Acid and gas produced from glucose, levulose, mannose, galactose, maltose, sucrose, lactose, raffinose, rhamnose, trehalose, salicin, aesculin, xylose, arabinose, glycerol, mannitol, dulcitol, sorbitol, adonitol, inositol, glycogen, dextrin, soluble starch, inulin, and pectin. Neither acid nor gas produced from melezitose, amygdalin, erythritol, and pentosan.

Growth on Endo medium: Colony: Medium, uniformly dark red, raised and convex, slight depression with a center of darker red. Greenish sheen. Medium: Dark red—frequent occurrence of sheen. Often resembling Es. coli.

Growth on eosin methylene blue medium: Colony: Medium to large in size, pinkish to purple in color, usually of dark center. Medium: Unchanged. Often resembling Aerobacter aerogenes.

Diagnosis: Non-motile rods, 0.8μ broad and 1.0 to 3.0μ long, conforming to the generic diagnosis. Acid and gas from the mono- and di-saccharides, pentose sugars, raffinose, rhamnose, trehalose, salicin; aesculin, glycerol, dulcitol, and other alcohols, but not erythritol, glycogen, most poly-saccharides, and pectin. No fermentation from melezitose, amygdalin, or pentosan. Acid and gas produced in litmus milk. Indol is produced. Gelatin is not liquefied. Isolated from creek water.

Aerobacter faeni n. sp.

Cultures	No.	5	Source
35	# 12	Hay	infusion
38		Hay	infusion

Morphology: Medium: Glucose-phosphate-peptone broth. Age: Twenty-four hours. Temperature: 37° C. Form: Short rods. Arrangement: Single and chains. Limits of size 0.8 to 1.5μ by 1.0 to 3.0μ . Ends: Rounded. Capsules: Present in twenty-four hour culture of litmus milk.

Endospores: Absent.

Motility: Non-motile.

Staining reactions: Gram negative. Granular with iodine.

Cultural characters:

Colony: Size 2-4 mm. in diameter, round, convex, opaque, shiny, amorphous. No coloration of medium.

Agar streak: Growth abundant, filiform, shiny and butyrous.

Plain broth: Cloudy.

Litmus milk: Acid and gas.

Natural media: Softening of potatoes and slight softening of carrots and parsnips.

Biochemical reactions: Indol produced. Acetyl-methyl-carbinol produced from glucose and sucrose. Nitrates reduced. Uses uric acid as a source of nitrogen. Methyl red negative. H₂S produced. Gelatin not liquefied. Skatol not produced. Diastase not produced.

Fermentation reactions: Acid and gas produced from glucose, levulose. mannose, galactose, maltose, sucrose, lactose, raffinose, rhamnose, trehalose, salicin, aesculin, xylose, arabinose, glycerol, mannitol, dulcitol, sorbitol, adonitol, inositol, glycogen, soluble starch melezitose, and pectin. Acid and gas not produced from inulin, dextrin, amygdalin, erythritol, or pentosan.

Growth on Endo medium: Colony: Small to medium in size, uniformly dark red in color, nearly flat, slightly depressed center, and bluish sheen.

Medium: Dark red.

Growth on eosin methylene blue medium: Colony: Small. Light purple, raised or convex. Medium: Color unchanged.

Diagnosis: Non-motile rods, 1.0μ broad and 1.0 to 3.0μ long, conforming to the generic diagnosis. Acid and gas produced from the mono- and disaccharides, including melezitose, from pentose sugars, raffinose, rhamnose, trehalose, salicin, aesculin, all the alcohols except erythritol, from glycogen, soluble starch, and pectin. No fermentation from amygdalin, inulin, or the pentosans. Acid and gas in litmus milk. Indol produced. Gelatin not liquefied. Isolated from hay infusion.

STUDIES ON THE PECTIN FERMENTING BACTERIA BELONGING TO THE GENUS BACILLUS

This group of organisms was studied by the same procedure employed for those of the genus Aerobacter.

The results of the detailed study of these organisms are included in Table II.

TABLE II. Cultural Reaction of Pectin-Fermenting Bacteria of the Genus Bacillus.

Cul- ture	Shape	Size	in μ	Arrange ment	Gram - reac-	Grai	nules	Cap- sules
No.		Wide	Long			Iodine	М. В.	
40 41	L. rod L. rod	0.3-0.5 0.4-0.5	2.0-3.5 2.0-3.5	S. Chain S. Chain	_			
'				1				
172	L. rod	0.5-0.6	1.5-3.0	S. Chain		+	_	
173	L. rod	0.6-0.7	3.0-4.0	S. Chain		+		

^{*}Culture numbers 172 and 173 are strains of Bacillus aceto-ethylicum.

L. rod = Long rod + = Positive reaction

+ = Positive reaction
- = Negative reaction

+r = Acidity followed by reduction

? = Questionable

A = Acid

G = Gas

Gl = Glucose

Su = Sucrose

M = Mannitol

Sa - Salicin

1, 2, 3, 4 = Proportional activity

N == Normal

S = Softened

S. Chain - Single and chains

TABLE II—(Continued)

Cul- ture	Spores	Motil- ity	Indol		Acetyl- Carl	Methyl binol	-	Nitrate reduc- tions	Uric Acid	M. R. reac- tion
No				Gl	Su	M	Sa			
40	+	+		-				+	+	all residents
41	+	+	-		-	07880×81	-	+	1	+
172	+ 1	+		_				+	1	+
173	+	+]	_		*****	-	+	1	+

^{*}Culture numbers 172 and 173 are strains of Bacillus Aceto-ethylicum.

TABLE II—(Continued)

Cul- ture	H ₂ S	Pro- teo- lysis	Skatol	Source	Broth		Litmu	ıs Milk		Dias- tase
No						A	G	R	C	1
40		+	1	Cornstalks	?	+	1 +	-		1 +
41	_	+	_	Cornstálks	?	+	+	+		+
N										
172	-	1		Stock	Cloudy	+	+	+	-	1+
173	—	1 -	-	Stock	Cloudy	+	1 +	+	-	+

^{*}Cultures Number 172 and 173 are strains of Bacillus aceto-ethylicum,

TABLE II—(Continued)

Cul- ture	Glucose		Levulose		Mannose		Galactose		Maltose		Suc	rose	Lactose	
No.	A	G	A	G	A	G	A	G	A	G	A	G	A	G
40 41	+r +r	++	+r +r	++	+r +r	++	+r +r	++	++	++	+r +r	++	+r +r	++
4														
172 173	+	++	+r +r	++	+r +r	++	+r +r	++	++	++	++	++	+r +r	++

^{*}Cultures Number 172 and 173 are strains of Bacillus aceto-ethylicum.

TABLE II—(Continued)

Cul- ture		ffi- se		am-		eha- ose		lezi- se		ali- in		nyg- alin		scu- in	Xy	lose
No.	A	G	A	G	A	G	A	G	A	G	A	G	A	G	A	G
40 41	+r +r	++	+r +r	++	+	++	+ +r	++	++	++	++		++	++	+ +r	++
2/E																
172 173	+r +r	++	+r +r	+	++	++	+r +r	++	+	++			+r +r	++	+r +r	++

^{*}Cultures Number 172 and 173 are strains of Bacillus aceto-ethylicum.

TABLE	II	Conti	inued)
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Cul- ture	Ara		GI	y-	Mar			ılci- ol	Sor	~~		oni- ol	1	osi- tol	Ery rit	
No.	A	G	A	G	A	G	A	G	A	G	A	G	A	G	A	G
40	+r	+	+r	+	$+\mathbf{r}$	+		_	+r	+				1	+	+
41	+r	+	+r	+	+r	+			+r	+	1—		-		+	?
172	+	+	+	+	+	+	?		+	+]		-		+	
173	+r	+	+r	+	+	+	?		+r	+		#White		en en en en en en en en en en en en en e	+	?

^{*}Cultures Number 172 and 173 are strains of Bacillus aceto-ethylicum.

Table II--(Continued)

Cul- ture				ol. rch		Inu- lin		Pec- tin		Pento- san		Lig- nin		Cellu- lose		
No.	A	G	A	G	A	G	A	G	A	G	A	G	A	G	A	G
40	+	+	+r	+	+	+	+r	+	1+	+	+r	+			1-	
41	+	+	+r	+	$+\mathbf{r}$	+	$+\mathbf{r}$	+	+	+	+r	+				-
1/4																
172	+	+	+r	+	+	+	?	+	1+	+	+r	+	1		Ī	
173	+	+	+r	+	+	+	?	+	+r	+	+r	+				

^{*}Cultures Number 172 and 173 are strains of Bacillus acetoethylicum.

Table II-(Continued)

Cul- ture	Po	Ca	rrot	Par	snip		Apple					
No.	Color	G	S	Color	G	S	Color	G	S	Color	G	S
40	Normal	1	3	Normal	2	4	Normal			Normal	3	4
41	Normal	1	3	Normal	2	4	Normal			Normal	2	4
172	Normal	1 1	3				Normal	-			1	
173	Normal	1	3	1			Normal	1	2			

^{*}Cultures Number 172 and 173 are strains of Bacillus acetoethylicum.

The pectin-fermenting bacteria of the spore-forming, aerobic type which were isolated and studied are very similar to the organism *Bacillus aceto-ethylicum*. The only significant difference observed was the ability to

liquefy gelatin.

Detailed study of these organisms revealed their inability to produce indol or acetyl-methyl-carbinol. They are further differentiated from the aerobic, non-sporeforming pectin fermenters by their ability to ferment pentosan. This latter characteristic may explain the ability of these organisms to ret cornstalks. The retting proceeds very slowly, starting with the certical layer of the slices of cornstalks. However, lignin and cellulose are not fermented.

A consideration of these organisms from the standpoint of their classification was first undertaken by the detailed study of strains 172 and 173 of Bacillus aceto-ethylicum. The results of this study show a very close agreement to the original Bacillus aceto-ethylicum described by Northrop (1919). The isolated cultures, with the exception of the ability to liquefy gelatin, are nearly identical with the former. Further differences were observed in the colony growth and in the type of maceration produced. The isolated forms completely destroyed all cellular tissue with the exception of the tracheal tubes. However, the effect of Bacillus aceto-ethylicum on potato is a softening and not so much a complete destruction.

These two related organisms seem to be very similar to Bacillus macerans as described by Schardinger (1897) and to Bacillus asterosperous described by Northrop, Ashe and Senior (1919). Beijerinck and den Dooren de Jong (1923) considered Bacillus asterosporus and Bacillus comesii and other similar retting and pectin fermenting organisms to be

grouped under the name Bacillus polymyxa.

DESCRIPTION OF THE PECTIN FERMENTING BACTERIA BELONGING TO THE GENUS BACILLUS

The two cultures isolated differ only in their ability to grow on solid media. The description applies to both cultures.

Bacillus aceto-ethylicum

Source: Cornstalk material.

No. 40 and 41.

Morphology: Glucose-phosphate-peptone broth. Age: Twenty-four hours. Temperature: 37° C. Form: Long, slim rods. Arrangement: Single or in short chains. Limits of size: 2.0μ to 3.5μ by 0.3μ to 0.5μ . Capsules: Not present in twenty-four hour cultures of litmus milk.

Endospores: Present-terminal.

Motility: Motile.

Staining reactions: Gram negative. No granules appeared with iodine.

Cultural characters:

Colony: Small, with a tendency toward spreading, grumose, edge-lobate, cochleate form, flat and clear.

Agar streak: Scant growth, beaded with lobated border.

Plain broth: Scant turbidity, no pellicle or ring.

Litmus milk: Acid and excessive gas production.

Natural media: Complete destruction of potato, carrot, parsnip, and apple tissue.

Biochemical reactions: Indol not produced. Acetyl-methyl-carbinol not produced. Nitrate reduction. Methyl red: Indefinite. H_2S not produced. Gelatin liquefied. Diastase produced. Uses uric acid as a source of nitrogen, sparingly.

Fermentation reactions: Acid and gas produced from glucose, levulose, mannose, galactose, maltose, sucrose, lactose, raffinose, rhamnose, melezitose, salicin, aesculin, xylose, arabinose, glycerol, mannitol, sorbitol, glycogen, dextrin, soluble starch, inulin, pectin, and pentosan. Slight fermentation was recorded from amygdalin and erythritol. Acid and gas not produced from dulcitol, adonitol, inositol, lignin, and cellulose.

Growth on Endo and E. M. B. media: Colonies were very small, convex and indicated very little change in the medium.

Remarks: Until further need for the separation of these organisms is evident, it is thought best to consider them as strains of Bacillus acetoethylicum.

SUMMARY AND CONCLUSIONS

The studies represented by this investigation have led to the differentiation of new species of bacteria which are capable of fermenting pectin. The organisms which were isolated and found to be pectin fermenting bacteria fall in three genera; Aerobacter, Bacillus, and Clostridium. These pectin fermenters are widely distributed in nature and are commonly associated with the decay of plant tissue.

The purified pectin employed, when used in a medium, has proven satisfactory for the isolation and identification of pectin-fermenting bacteria. It is suggested that further study of the fermentation of this purified pectin may throw some light on the chemistry of pectin as well as on the systematic relationships of the organisms.

The pectin-fermenting bacteria, as a group, are characterized by active starch fermentation, the presence of granules when stained with iodine, the ability to ferment a large number of sugars, alcohols, glucosides, and polysaccharides, and the ability to disintegrate plant tissue.

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^{*}Original not seen.

^{*}Original not seen.

^{*}Original not seen.

SUCTORIA OF THE LARGE INTESTINE OF THE HORSE:

ALLANTOSOMA INTESTINALIS GASSOVSKY, A. DICORNIGER SP. NOV., AND A. BREVI-CORNIGER SP. NOV.

TA-SHIH HSIUNG

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Accepted for publication Oct. 1, 1928.

In the course of a microscopic investigation of the protozoa which inhabit the large intestine of the horse at least three distinct species of Suctoria were observed. Up to the present time the writer has examined fifteen horses which were sacrificed for the Operative Surgery and the Postmortem Technique classes of the Division of Veterinary Medicine of Iowa State College. Fresh feces of several other horses were also examined.

In the material taken from the colon of horse No. 6, the writer noted a suctorian (Fig. 1) which agrees with the general description of Allantosoma intestinalis Gassovsky, except for some minor differences. On two other occasions this suctorian was found in the fresh feces of horses. Gassovsky states that A. intestinalis bears one to seven suckers on each end of the body, but in the material from none of these three horses has the writer found even one specimen bearing only one sucker on each end of the body. So far as the writer can find, the number of suckers on either end of A. intestinalis varies from three to seven. The measurements as given by Gassovsky for A. intestinalis are 16.65μ x 5.27μ . While the length of the body of A. intestinalis, measured by the writer, varies from 33.60μ . with a mean length of 47.7μ , the width of the body varies from 18.37μ , with a mean width of 26μ . The diameter of the macronucleus is about 10μ . Some of them were attached to the bodies of parasitic ciliates Cycloposthium bipalmatum and Blepharocorus curviquia.

In the material taken from the colon of horse No. 12, the writer noted a second species of Suctoria. This new suctorian (fig. 2) differs from A. intestinalis mainly by its smaller macronucleus as well as by its smaller body size and its consistency in bearing only one tentacle on each end of the body. It should be noted here that not a single specimen of A. intestinalis type was present in the material in which this new suctorian was found. The tentacles of this new suctorian, which are bowed toward each other on the ends of the body, suggest in appearance a pair of horns. Therefore the name Allantosoma dicorniger is suggested for this new species of Suctoria. The body is more or less sausage-shaped, bearing one incurved tentacle on each end. The outline of the distal end of the tentacle somewhat resembles that of a boot. The surface which lies between these two tentacles is nearly flat, while the remaining surface is convex. The cytoplasm, as in A. intestinalis, is filled with numerous refractile granules. A more or less spherical macronucleus with a mean diameter of 6 µ is located near the center of the body. A small spherical micronucleus lies by the side of the macronucleus. A single contractile valuole can usually be seen near the macronucleus. The length of the body of this new suctorian varies from $20{\text -}33\mu$, with a mean length of 27μ ; the width of the body varies from $10{\text -}20\mu$, with a mean width of 16.4μ . The ratio between the length and the width of the body ranges from 1.2-1. to 2.5-1, with a mean ratio of 1.6-1. It has been found only in the colon. Every individual observed was unat-

tached to any other organism.

In the material taken from the caecum of horse No. 15, the writer noted still a third species. At the first glance this suctorian resembles A. dicorniger in general form, but upon closer and more critical examination there are to be found several important features which separate this suctorian from A. dicorniger. Not a single specimen which could be identified as either A, intestinalis or A, dicorniger was present together with this species. Because of its short tentacles, the name Allantosoma brevi-corniger is suggested for this new species. The body of this new suctorian (fig. 3) resembles that of an elongated A. dicorniger. It also bears one slightly incurved tentacle on each end of the body. The tentacles are shorter and more slender than those of A. dicorniger. The sucker, which is at the distal end of the tentacle, does not form a boot-shaped expansion as does that of A. dicorniger. Another difference is that the cytoplasm of this species is nearly homogeneous, while that of A. dicorniger and A. intestinalis contains numerous refractile granules. An oval macronucleus, with a mean length of 6.8μ and a mean width of 4.4μ , is usually located in the center of the body. A small spherical micronucleus lies by the side of the macronucleus. A single contractile vacuole is usually located near the macronucleus. The length of the body of this new suctorian ranges from 23-36 μ . with a mean length of 29.6μ ; the width of the body ranges from $7-11\mu$, with a mean width of 8.6 μ . The ratio between the length and the width of the body ranges from 2.4-1 to 4.1-1, with a mean ratio of 3.4-1 as compared to 1.6-1 in A. dicorniger. It is often found attached to the body of the ciliate Paraisotricha colpoidea by one tentaele. It has been found only in the caecum so far.

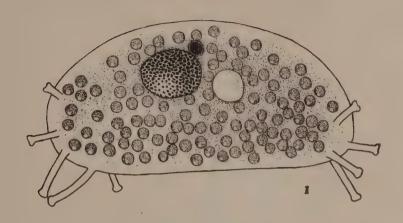
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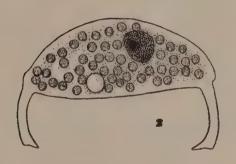
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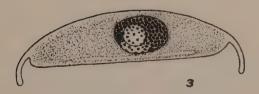
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EXPLANATION OF PLATE

- Fig. 1. Allantosoma intestinalis Gassovsky. Magnification X 1707.
- Fig. 2. Allantosoma discorniger sp. nov. Magnification X 1707.
- Fig. 3. Allantosoma brevi-corniger sp. nov. Magnification X 1707.









DI-ALKYL DI-ARYL LEAD COMPOUNDS. ANTI-KNOCK STUDIES

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Accepted for publication Nov. 6, 1928.

INTRODUCTION

The most widely used anti-knock compound in internal combustion engines is tetraethyl lead. This is also one of the most effective compounds and is commonly used as a standard of comparison for other anti-knock compounds.

If we assign to tetraethyl lead a relative molecular effectiveness of 118 units it is known that diethyl diphenyl lead, on this basis, has a value of 110¹. In other words, the replacement of two ethyl groups in tetraethyl lead by two phenyl groups gives a compound that is only slightly less effective than tetraethyl lead. This result naturally suggested the replacement of the two ethyl groups by other alkyl groups. Because of the recent availability of the butyl alcohols, a study has been made of the four hither-

to unknown dibutyl diphenyl lead compounds.

The anti-knock effectiveness of three of these compounds has been found to be high, but not as great as that of diethyl diphenyl lead. Unfortunately, it was impossible to get any satisfactory tests with what is probably the most interesting of these four new compounds: namely, the ditertiary-butyl diphenyl lead. This compound has a claim to extra importance because it is the first of the many organolead compounds that has a tertiary radical attached to lead². The di-tertiary-butyl diphenyl lead (unlike the other dibutyl diphenyl lead compounds) is a solid, and organolead compounds which are solid at room temperature are very sparingly soluble in gasoline and, therefore, no reliable testing of their anti-knock properties can be obtained. In a series of studies, now in progress, the effectiveness of tertiary groups in more soluble organolead compounds is being investigated.

EXPERIMENTAL PART

The 4 compounds were prepared according to the following reactions:

 $(1) \quad C_6H_5MgBr + PbC1_2 \longrightarrow (C_6H_5)_4Pb$

 $\begin{array}{ll} \text{(1)} & C_6 H_5 H_6 B I + I b C I_2 \longrightarrow (C_6 H_5)_4 I b \\ \text{(2)} & (C_6 H_5)_4 P b + 2 B r_2 \longrightarrow (C_6 H_5)_2 P b B r_2 + 2 C_6 H_5 B r \\ \text{(3)} & (C_6 H_5)_2 P b B r_2 + 2 C_4 H_9 M g B r \longrightarrow (C_4 H_9)_2 P b (C_6 H_5)_2 + \\ \end{array}$

(3) $(C_6H_5)_2PbBr_2 + 2C_4H_9MgBr \longrightarrow (C_4H_9)_2Pb(C_6H_5)_2 + 2MgBr_2$

Tetraphenyl lead was prepared according to the method of Pfeiffer and Truskier³. Subsequently, Gilman and Robinson⁴ devised improved direc-

¹Boyd, International Critical Tables, 2, 162-163. An article entitled: "Quantitative effects of some compounds upon detonation in internal combustion engines."

²Gilman, Sweeney and Kirby (THIS JOURNAL, 2 (1928)) have reported on the 4 butyl triphenyl lead compounds and as stated in Ref. 3 of that article Dr. Balassa was the first to prepare an organolead compound having a tertiary group attached directly to lead.

tions for its preparation from the Grignard reagent and lead chloride. Diphenyl-lead-dibromide was obtained in almost quantitative yields by the method of Polis⁵, and was used directly after its preparation because of its instability, particularly when exposed to light. The dibutyl diphenyl lead compounds were prepared by a standard procedure from the appropriate Grignard reagents. The tert.-butylmagnesium chloride was obtained after the directions of Gilman and Zoellner⁶. Two particular reasons for the success in obtaining di-tertiary-butyl diphenyl lead are: first, the addition of the Grignard reagent to the diphenyl-lead-dibromide; and, second, the use of an insufficient quantity of Grignard reagent. Both of these procedures diminished the reducing tendency of tert.-butylmagnesium chloride.

The compounds were analyzed for lead by the method of Gilman and Robinson⁷.

DI-n-BUTYL DIPHENYL LEAD.—The Grignard reagent was added slowly to 26 g. of diphenyl-lead-dibromide covered with 50 c.c. of ether. The dibromide dissolved slowly, and after all the Grignard reagent had been added stirring was continued for one-half hour. The reaction mixture was then hydrolyzed by iced ammonium chloride; and after successively washing the ether solution with water, dil. sodium hydroxide and then with water again, it was dried by sodium sulfate. On removal of the ether by evaporation, 18 g. of a yellowish oil was obtained. At a pressure of 14 mm. the compound underwent decomposition (accompanied by a mild puff) depositing a metallic mirror.

Analysis—Calc. for $C_{20}H_{28}Pb$: Pb, 43.58%. Found: Pb, 43.18 and 42.7%.

DI-iso-BUTYL DIPHENYL LEAD.—This compound was prepared like the di-n-butyl diphenyl lead from 26 g. of diphenyl-lead-dibromide. The yield of yellowish oil was 16 g. It is soluble in the common organic solvents, and on standing undergoes some decomposition that is accompanied by the deposition of small quantities of a yellow precipitate.

Analysis—Calc. for $C_{20}H_{28}Pb$: Pb, 43.58%. Found:Pb, 43.08 and 43.53%.

DI-sec-BUTYL DIPHENYL LEAD.—The yellowish oil obtained in this preparation (following the general directions given for di-n-butyl diphenyl lead) is less stable than the n- and the iso- analogues. Such decomposition can be retarded by keeping the compound cold, but even under such conditions a solid decomposition product is slowly formed.

The comparative instability of our di-sec-butyl diphenyl lead is in agreement with a general observation that "secondary alkyl groups give the compounds a much lower stability than the corresponding primary groups".

³Pfeiffer and Truskier, Ber., 37, 1125 (1904).

⁴Gilman and Robinson, J. Am. Chem. Soc., 49, 2315 (1927).

⁵Polis, Ber., 20, 3332 (1887).

^{&#}x27;Gilman and Zoellner, J. Am. Chem. Soc., 50, 425 (1928).

^{&#}x27;Gilman and Robinson, ibid., 50, 1714 (1928).

^{*}Calingaert, "Organic Compounds of Lead," Chemical Reviews, 2, 43 (1926). This is the most recent and authoritative treatise on organolead compounds.

Analysis—Calc. for $C_{20}H_{28}Pb$: Pb, 43.58%. Found: Pb, 44.21 and 44.6%.

DI-tert-BUTYL DIPHENYL LEAD.—In a first preparation, the diphenyl-lead-dibromide was added slowly to the Grignard reagent. A vigorous reaction took place, and apparently the tertiary-Grignard reagent acted in part as a reducing agent inasmuch as considerable metallic lead separated.

In another preparation, an insufficient quantity of the Grignard reagent was added to the dibromide with better results. The reaction took place at once and was accompanied by the formation of a yellow product. After working up the reaction mixture in the customary manner the solid products were purified by dissolving in hot alcohol and then partially precipitating by the addition of water. The compound is readily soluble in most organic solvents, and crystallizes from ether as microscopic needles. The yield of compound that sinters at 174° and melts unclearly at 177° was 32%.

Analysis—Calc. for $C_{20}H_{28}Pb$: Pb, 43.58%. Found: Pb, 43.46 and 43.41%.

It is worthy of note that even these relatively heavy molecular organolead compounds induced a malaise somewhat characteristic of volatile lead compounds.

RELATIVE ANTI-KNOCK EFFECTIVENESS OF THE COMPOUNDS

"Solutions of the three liquids were made up in a commercial gasoline at concentrations equivalent to approximately 2.0 grams of metallic lead per gallon of gasoline. These solutions were matched in two knock testing engines against the same gasoline containing increasing amounts of tetraethyl lead. The results given below are expressed as moles of tetraethyl lead necessary to produce the same anti-knock effect as one mole of the compound.

di-normal butyl diphenyl lead0.3	33
di-isobutyl diphenyl lead0.3	38
di-secondary butyl diphenyl lead0.4	

From these results one may conclude that both the *n*-butyl and the *iso*-butyl compounds are about one-third as efficient as tetraethyl lead on a *mole* basis. The *sec*-butyl is somewhat more efficient, but not quite one-half as much as tetraethyl lead.

The stability of the compounds in gasoline solution is of the same order when no solvent is used: namely, the *normal* is much more stable than the

iso and secondary compounds."

As mentioned in the "Introduction", no satisfactory test could be made with the solid *tert*,-butyl compound.

SUMMARY

The four di-butyl diphenyl lead compounds have been prepared and tested for their relative anti-knock effectiveness.



THE PREPARATION OF SOME PERFUMES AND FLAVORING EXTRACTS FROM FURFURAL AND ITS DERIVATIVES. ESTERS OF β-FURYLACRYLIC ACID¹

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INTRODUCTION

In connection with the preparation of ethyl β -furylacrylate, details of which were reported recently in THIS JOURNAL², we were impressed with the pronounced aromatic and pleasant odor of this ester. This suggested a study of related esters that might be of equal or greater attractiveness in investigations concerned with the utilization of furfural and its derivatives. A number of these esters, most of them new compounds, have been prepared and tested for their perfume and flavoring qualities. The distinctly favorable reports on these compounds have warranted the extension of this investigation to other derivatives of furfural.

EXPERIMENTAL

Gibson and Kahnweiler³ prepared methyl and ethyl β-furylacrylate; Herzog, Hildesheimer and Medicus' prepared the isoamyl ester; and Gilman and Pickens⁵ prepared the benzyl ester in studies on the correlation of structure with physiological action.

The esters reported here were prepared by a wide variety of methods. No effort was made to determine optimal conditions. Unquestionably the yields can be significantly improved.

METHYL ESTER.—This ester was obtained in a 26.3% yield by heating potassium furylacrylate with an equimolecular quantity of dimethyl sulfate for several hours on a water bath.

ETHYL ESTER.—See Ref. 2.

n-PROPYL ESTER.—A 77.7% yield of this ester was obtained in a 0.4 mole run from β -furylacrylic acid chloride and n-propyl alcohol. The alcohol in 100 c.c. dry benzene was added to 0.4 mole of the acid chloride in 150 c.c. of benzene and the mixture refluxed for 4.5 hours or until evolution of hydrogen chloride ceased. The product was worked up in a customary manner by fractional vacuum distillation.

^{&#}x27;This is one of a series of studies in organic chemistry concerned with the utilization of agricultural wastes. The authors gratefully acknowledge help from the Industrial Science Research Fund for the defrayal of expenses incurred in this investigation.

Gilman, Brown and Jones, THIS JOURNAL, 2, 317-319 (1928).

³Gibson and Kahnweiler, Am. Chem. J., 12, 314 (1890).

^{&#}x27;Herzog, Hildesheimer and Medicus, Z. angew. Chem. 34, 57 (1921).

This article mentions the "amyl" ester, but gives neither an analysis nor a description of the properties of the ester.

Gilman and Pickens, J. Am. Chem. Soc., 47, 245 (1925).

The β -furylacrylic acid chloride used in this and some other preparations was obtained in a 90% yield by heating 0.5 mole of the acid, 0.75 mole thionyl chloride, and 350 c.c. of benzene. The time of heating was 2.5 hours, and in an experiment where the period of refluxing was 3 hours the yield was 80%. The acid chloride boiled at $106.5^{\circ}/6$ mm. and $121-123^{\circ}/14-16$ mm.

ISO-PROPYL ESTER.—When prepared according to the method

used with the *n*-propyl ester, the yield was 46%.

In a first experiment, a Claisen condensation was carried out between furfural and isopropyl acetate, using sodamide as the condensing agent. After all the furfural had been added at -5° to 0°, the temperature was allowed to rise slowly to that of the room, and a vigorous reaction took place at 17°. After working up the reaction mixture in the customary manner (see Ref. 2) it was noticed that considerable unaltered sodamide was present. The yield of ester by this method was 10%.

n-BUTYL ESTER.—This ester was obtained in a 44.3% yield by refluxing on a water bath for 3 hours a mixture of 0.25 mole furylacrylic acid, 0.75 mole n-butyl alcohol and one mole of dil. sulfuric acid (prepared from one part acid with two of water). This was the only ester of those prepared that did not appreciably darken (over a 5 month period) on standing.

n-AMYL ESTER.—From 0.5mole of furylacrylic acid, 1.5 moles n-amyl alcohol and 2 moles dil. sulfuric acid and a 5 hour period of refluxing there was obtained a 20% yield of this ester. Considerable difficulty was experienced in a first vacuum distillation, the ester boiling over a wide range: namely, 121-140°/2-2.5 mm. On redistillation at 4 mm. the compound boiled at 119-120.5°.

BENZYL ESTER.—Sodium furylacrylate (0.5 mole prepared by evaporating to dryness the solution obtained from furylacrylic acid and sodium hydroxide) was heated with 0.5 mole benzyl chloride. The yield was 22.4%. During the 8 hour period of heating the temperature (of the oil bath) was gradually raised from 130° to 230°.

FURFURYL ESTER.—Furfuryl alcohol (0.45 mole in 50 c.c. of benzene) was added very slowly to a refluxed solution of 0.4 mole of furylacrylic acid chloride in 150 c.c. of benzene. The mixture darkened somewhat during the reaction, which was extended for one hour after the addition of all of the alcohol. In distilling off the benzene at 740 mm., the mixture decomposed at 93°, leaving a carbonaceous residue that contained some furylacrylic acid.

The experiment was repeated, but this time the solvent was removed by vacuum distillation. The residue was crystallized 5 times from petroleum ether (b.p. 42-60°) by chilling with an ice-salt freezing mixture. The impure portion separated first, by such crystallization. The several fractions of purer ester were finally crystallized from 95% alcohol as well defined rhombohedral crystals melting at 52°; the yield was 44.5%.

Each ester reported here was hydrolyzed by alcoholic potash, and the acid (obtained by acidification with hydrochloric acid) was identified as β -furylacrylic acid by means of a mixed melting point determination made with an authentic specimen. The esters hydrolyze with great ease. In

				20	Saponi- fication			Analy	ysis	
	i		d 20	n	Equiv-	Mol.	Cal	c.	Fou	nđ
Ester	M.P.	B.P.	4	D	alent	Wt.	%C	%H		%H
Methyl	27	89/5		1.4447	1	152				
	1	mm.						Ī		
Ethyl		117/8		1.5286	161	166				
	[mm.			:					
n-Propyl		119/7	1.0744	1.5229	167	180	66.66	6.66	$\overline{65.85}$	6.58
	ĺ l	nım.			1					
iso-Propyl		98/41/2	1.0503	1.5146	176	180	66.66	6.66	66.31	6.62
	ĺĺ	mm.								
n-Butyl		121/5	1.0482	1.5129	184	194	68.04	7.21	67.54	7.42
	[[mm.					ĺ	í		
n-Amyl	Ţ Ţ	119/4	1.0322	1.5083	197	208	69.23	7.69	69.37	7.30
		mm.			1					
Benzyl	42-43	202/12				228				
	1 17	mim.			1 1					
Furfurvl	52	decomp.			206	218	66.06	4.58	65.71	4.70

TABLE I. CONSTANTS AND ANALYSIS OF ESTERS OF β -FURYLACRYLIC ACID.

fact, the amyl ester is appreciably hydrolyzed by water on very short standing at room temperature.

REPORT ON PERFUME AND FLAVORING QUALITIES

The authors are indebted to Fritzsche Brothers, Inc., of New York for the following certificate of analysis.

METHYL ESTER.—Resembles methyl and benzyl cinnamate with a suggestion of clove. Should prove useful in perfumery for disguising and obtaining new notes. Acetophenone odor; slight raisin-like taste.

ETHYL ESTER.—Would make an excellent maple, walnut and coffee constituent

n-PROPYL ESTER.—Of more interest in flavors than perfumes. Might prove useful in pear. Fatty odor, like higher esters of caprinic and tiglic acids. Dried apple peels.

iso-PROPYL ESTER.—Should prove valuable not only for perfumes but also for flavors. Closely resembles methyl cinnamate, and when dry reminds of caraway. Due to its fruity cinnamate character it should prove valuable for use in champaca.

n-BUTYL ESTER.—When dry resembles methyl anthranilate, except that its odor is cold. Remindful of amyl or iso-butyl salicylate.

n-AMYL ESTER.—In dry stage resembles iso-butyl and amyl salicylates, but has a more fruity odor. Seems very persistent, and has held on a blotting paper for 24 hours. Sharp, sour odor reminding in the last stages of rose. Apple and slight raisin taste.

BENZYL ESTER.—Odor like benzyl benzoate. Taste quite characteristic of raisin.

FURFURYL ESTER.—Very slight odor, not very characteristic.

The physiological action of these esters has not yet been determined. The authors are grateful to Fritzsche Brothers, Inc., of New York for the detailed tests; to John A. Leermakers for a part of the experimental work; and to the Miner Laboratories of Chicago for liberal supplies of furfural.

SUMMARY

A number of esters of β -furylacrylic acid have been prepared and tested for their perfume and flavoring qualities.

THE ISOLATION OF SOME NITRIFYING ORGANISMS1

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INTRODUCTION

Much general information regarding the process of nitrification has been available for many years. In fact, the production of nitre by allowing animal and vegetable matter rich in nitrogen to undergo the process of decay under carefully controlled conditions, has been an important industry for ages in India; and even in some of the European countries, especially in France, during the years when she was at war with England, whose superior naval power prevented the importation of nitre. Purely empirical instructions were frequently given by the governments in regard to the aeration, temperature, and moisture conditions which should be maintained in the production of nitrates. The nature of the process, however, was unknown.

The early theories of nitrification were chiefly chemical, such as those of Kuhlmann (30) and Dumas (15). The oxidation occurring in soil was thought to be similar to catalytic reactions known at the time, the soil acting as a catalyst.

Pasteur (43) suggested the biological theory in 1862. It slowly gained ground, but it was not until the classical experiments of Schloesing and Muntz (46, 47) in 1877-78 that this theory was definitely proved. These authors also tried to isolate the specific organisms causing the oxidation, but failed, as did several other workers of that time.

That nitrification is an important phenomenon in nature is readily seen from the facts, (1) that higher plants, with few exceptions, grow better with nitrates as a source of nitrogen than with any other source, and (2) that nitrates are the end products of protein decomposition in sewage as well as in soil.

REVIEW OF LITERATURE

Interest in the isolation of the nitrifying organisms began with the proof that nitrification is a biological process. Schloesing and Muntz (46, 47) succeeded in showing that heat and antiseptics would stop the process and that it would begin again as soon as a very small amount of fresh soil was introduced into the medium. They failed, however, to isolate the organisms responsible for the nitrate production. They believed that the crganisms were yeast-like forms. They proved that the organisms were

Part II of a thesis submitted to the graduate faculty of the Iowa State College in partial fulfillment of the requirements for the degree Doctor of Philosophy.

²Formerly Research Fellow in Soils. During the course of this work the author has discussed his problem with Dr. P. E. Brown, Dean R. E. Buchanan, Dr. Paul Emerson, Dr. Fred Smith, and Dr. C. H. Werkman. For their encouragement, helpful suggestions and criticisms he wishes to express his appreciation. He is especially indebted to Dr. P. E. Brown for reading and criticising the manuscript.

absent from air, present in small numbers in ordinary water, more abundant in sewage, and very abundant in soil. Ninety degrees centigrade was found sufficient to inhibit the reaction and 100 degrees centigrade invariably killed the organisms. Soils treated with chloroform regained nitrifying activity more slowly than similar soils after being heated.

Heraeus (23) in studying sewage, isolated twelve organisms which he called alpha, beta, gamma, etc., of which he claimed the rho, sigma, phi and chi forms had nitrifying powers. His work has not been repeated, and

subsequent workers have doubted the validity of his claims.

Warington (55, 56) carried out extensive and careful experiments with nitrifying organisms. He found that nitrification takes place in two stages; first, the oxidation of ammonia to nitrites; and second, the oxidation of nitrites to nitrates. He found further that nitrification would take place in the presence of urea, asparagine, milk or urine.

He isolated some organisms by means of gelatin and agar plates from his nitrifying cultures, but they would not nitrify when introduced into mineral solutions. Some of the organisms in his cultures were like those described later by Winogradsky, but since they were not isolated by a plate

method, they probably were not pure.

The Franklands (16), after two years of study, using chiefly the dilution method, believed they had a pure culture of nitrifiers. They described the organism as a short rod, 0.8 micron long and nearly as thick. They cultivated this organism in mineral solution for nearly three years.

The first American investigators to study the problem were Jordan and Richards (25), who proved that nitrifiers were invariably present in ordinary water; and although they failed to isolate the organism by the celatin plate method, they claim to have succeeded by means of dilution. Their criteria of purity were (1) oxidation of ammonia and (2) the microscopic appearance of the organisms.

Leone (31) believed that certain organisms may successively produce nitrates and reduce them, according to the environmental conditions.

Winogradsky (60, 61) began his studies on the nitrifying organisms in 1890. He had made outstanding contributions to our knowledge of the sulfur and iron bacteria and was attracted to this field perhaps because here was a group of organisms which, like those he had been studying, had the power of oxidizing inorganic materials. He succeeded in isolating a metile, ovoid, organism which he named Nitrosomonus, which would oxidize ammmonia to nitrites very rapidly in suitable media and would not grow on the gelatin plates. Five species of organisms, which he called alpha, beta, gamma, delta and epsilon, were difficult to eliminate from his enrichment cultures. Of these, the beta and epsilon forms were described as follows: "Beta, un petit öidium interessant, formant sur la gelatine des colonies roses. Epsilon un organisme étrange n'appartenant probablement pas aux bacteries, mais au groupe des especes bourgeonantes (Sprosspilze)." The others were a micrococcus, a long rod and a short rod, respectively.

By using recrystallized salts and twice distilled water, he finally succeeded in eliminating all these forms except the epsilon. To eliminate this organism he seeded some magnesium carbonate sediment from a nitrifying culture on gelatin plates. The epsilon organism grew well, forming visible colonies. Here and there on the plates were found carbonate particles re-

mote from the epsilon colonies, which by examination were found to be covered with small ovoid organisms. When this organism was transferred to a mineral solution it oxidized ammonia to nitrites and was found to be free from the epsilon form by its failure to show growth on gelatin. This process has since been known as the inverse gelatin method of isolating nitrifiers.

Winogradsky expressed disappointment that his alpha, beta, etc., forms could not nitrify ammonia. He later isolated other species of the genus *Nitrosomonas*, and also a nitrite-oxidizing organism which he named *Nitrobacter*. This, too, was a small ovoid organism whose length was never more than one-half micronillimeter and the thickness much less.

Working alone and with Omeliansky (58, 59) he carried out many physiological studies on these organisms. He determined the ratio of nitrogen oxidized to carbon reduced and found it to be 35:1 for Nitrosomonus and 40:1 for Nitrobacter. By determining the total carbon at the time of inoculation and the total and organic carbon at the end of the incubation period, he was able to show that carbon came into the solution in an amount equal to the organic carbon formed. Soluble organic matter was found to be very toxic to these organisms.

Later Winogradsky improved his methods for the isolation of these organisms by using silica gel plates. A finely drawn glass tube or rod was used for transferring the minute microscopic colonies. Inoculations were made into alkaline broth and if no growth occurred, the cultures were considered pure. It is a significant fact, as pointed out by Gibbs (19), that Winogradsky's work has never been repeated in its entirety!

Godlewsky (20, 21) succeeded in confirming Winogradsky's results with respect to the source of carbon. He also showed that carbon dioxid

is necessary for the metabolism of the organisms.

Burri and Stutzer (10, 11) isolated a nitrate-forming organism. They claimed it would grow in broth. However, Winogradsky obtained one of their "pure" cultures and isolated from it not only the nitrate organism but also two other forms. The rather severe criticism by the Russian bacteriologist was answered by Stutzer and Hartleb (50), who pointed out the difficulties which Winogradsky had encountered in his isolation studies. Later Stutzer (49) isolated and studied the nitrifiers and showed that, while most organic matter is toxic, soil extract, "abkochung", is not. Still later these authors isolated an organism which they called Nitromicrobium and another called Hyphomicrobium. Their description of the latter, as Gowda (22) points out, resembles that for certain actinomycetes.

Omeliansky (38) reports some experiments which were designed to show that pure cultures of nitrifiers could not nitrify urine, urea, egg albumin, asparagin, or bouillon, as had been reported. He took special precautions to eliminate all traces of ammonia from all cultures at the beginning. The organisms isolated by Winogradsky's method were used. No trace of nitrites or nitrates appeared. This worker later, 1899 (39), introduced the gypsum block as a suitable solid substratum for growing these organisms, when the usual solution of salts was used. He found that small drop-like colonies appeared in 3 to 4 days, and in 10 to 14 days the colonies were 0.25 to 0.50 mm. in diameter. He (40) also grew the nitrite-forming organism on pads of high grade filter paper, stitched together with fine thread, sterilized in petri dishes, and soaked with a mineral solution.

Fremlin (18) used agar, gelatin and silica gel plates for isolating the Nitroso-bacterium. His experiments tend to show that the organism often loses its power of oxidizing ammonia when grown in organic media, but that this power is regained by passing through sterile soil. Some cultures, however, showed oxidation on the first transfer. Fifty-three culture-flasks were seeded with pieces of beef-broth agar containing the organisms and in 20 of them an oxidation of the nitrogen occurred. In nineteen similar flasks inoculated with pieces of agar from the same plates, but taken from portions of the plates where no growth could be detected, there was no oxidation. The organism studied was ovoid, resembling Winogradsky's Nitrosomonas.

Boullanger and Massol (7, 8), using the silica gel plates, claim to have isolated both nitrifying organisms. They tested several ammonium compounds in various concentrations and found that 30 grams of ammonium sulfate per liter greatly retarded nitrite formation, and 20 grams of sodium nitrite per liter hindered nitrate formation. Thirty-seven degrees centigrade was found to be the optimum temperature for nitrite formation and at 45 degrees the reaction stopped. For the nitrate former 55 degrees was required to stop the reaction.

These workers tested several materials such as cinders, crushed porcelain, pumice, crushed bricks and sand placed in the medium to increase aeration. Of these materials, cinders, "scories," was found to be the best for both nitrite and nitrate formation.

Using Winogradsky's inverse gelatin method described above, Wimmer (57) isolated the two nitrifying organisms which he said were similar to those isolated by Winogradsky and should, therefore, belong to the same genera. These would not grow in bouillon. He studied the effects of soluble organic matter and found that it was toxic in the higher concentrations. Using sand reduced the toxicity of these organic materials considerably.

Perotti (44) isolated a nitrite-forming coccus by means of the silica gel plates. It was 0.6 to 0.8^{μ} in diameter and appeared slightly ovoid at times. It was motile by means of one flagellum, gram negative, and was usually found in groups of two to six cells.

While studying some hydrogen-oxidizing organisms, Kaserer (27) isolated two species of organisms which he named *Bacillus nitrator* and *Bacillus azotofluorescens*, respectively. The first of these he found would oxidize ammonia to nitrates without forming nitrites. The second would oxidize ammonia, liberating free nitrogen. These studies have never been confirmed.

Thomsen (51) isolated some nitrifying organisms from sea water. They were like those described by Winogradsky and were found chiefly in waters close to the shore. They were seldom found beyond the depth of 100 meters.

Coleman (12) demonstrated that dextrose in low concentrations in soil and sand was actually stimulating to nitrification. In higher concentrations it became first indifferent and finally toxic. Sucrose, glycerin and lactose also were stimulating in low concentrations, but less so than dextrose. Peptone and urea were toxic in comparatively low concentrations. The optimum moisture was found to be 16 percent. Coleman emphasized

the importance of aeration in the process and he found carbon disulfide very toxic to the organisms.

Owen (42) reports a study on the effects of carbonates on nitrification. It is doubtful if he had pure cultures, for his photomicrographs do not in-

dicate it and his methods as described are rather inadequate.

Makrinoff (34) studied the effects of organic substances on nitrifying bacteria grown on gypsum blocks, in soil, and in solutions to which soil had been added. He found that a longer time was needed before oxidation took place in solutions to which considerable soil had been added than in pure mineral solutions. Soil extracts were more toxic in solution cultures than when used with the gypsum blocks. One nitrite culture was obtained from Omeliansky and the author isolated others by means of silica gel plates. The organisms studied were similar to those isolated by Winogradsky.

Millard (37), using the dilution method, found that 100,000 nitrifiers were present per gram in the soil studied. There were none present in

dung.

Beijerinck (3) isolated a nitrate-forming organism from the soils of Delft by means of silica gel and washed agar plates. It resembled *Nitrobacter*, but would grow in organic media. He found, however, that this organism lost its power to oxidize nitrites when so grown. He named the oxidizing form *Nitrobacter oligotrophum* and the non-oxidizing form, *Nitrobacter polytrophum*. This latter form did not regain its power to oxidize nitrites after being grown in organic media.

A membrane formed on the surface of his crude cultures, which he called mother of nitrate, "Nitratmutter". This contained many organisms including several species of the Actinomyces. Most of these were readily eliminated in the enrichment cultures, but two species, Actinobacillus oligocarbophilus and Actinobacillus paulotrophus, of the order Actinomycelales, and a short rod, which he named Bacillus nitroxus, were harder to eliminate.

Joshi (26) described a nitrifying organism which was undoubtedly one of the Actinomyces. His description of the culture and his photomicrographs are quite convincing. This organism produced nitrites from ammonia in Omeliansky's solution. Three rod-shaped organisms, which he

called intruders, are mentioned, but not described.

He studied the effects of dextrose, asparagine and urea on the organisms. One-tenth of a gram of dextrose in 50 c.c. of solution stimulated nitrite production, while 0.2 gram stopped it; 0.1 gram of asparagine stimulated nitrite production, but 0.2 gram retarded it; both 0.1 and 0.2 gram of urea stimulated nitrite production. Carbon dioxid and coal gas stimulated nitrification and calcium carbonate was found superior to magnesium carbonate as a base. The thermal death point was between 70 and 80 degrees centigrade and the optimum for growth was between 25 and 35 degrees centigrade.

Hopkins and Whiting (24) studied the effects of nitrification on the solubility of phosphates and found that the nitrite-forming organism had a much greater solvent effect on these materials than the nitrate-forming

organism.

Russel and Bartow (45) report the isolation of the nitrifiers from activated sludge. The nitrite organism produced 0.1 to 0.2 parts per million

of nitrites in sterilized sludge and the two growing together formed traces of nitrites and nitrates. The fresh sludge in the same time produced 12 parts per million. The nitrogen analysis of the sludge used is not given, so the results are difficult to interpret properly.

Allen and Bonazzi (1) conducted experiments on nitrification. They pointed out the need for physiological studies on the nitrifying organisms, which Bonazzi (4, 5, 6) later carried on. This worker isolated a coccus which formed nitrites quite rapidly and named it *Nitrosococcus*. He found that aeration, agitation of the cultures, and free carbon dioxid were necessary for the most rapid nitrification in liquid media.

The broth test, using a loopful of culture for inoculum, and the microscopic examination of the cultures, were his criteria of purity. This was criticized by Gibbs (19), who claimed that a larger inoculum than Bonazzi used, namely ½ e.c. was necessary to insure the absence of contaminators.

Gibbs (19) reports the isolation of the nitrifiers and certain physiological studies. He found that the method used by Bonazzi gave conflicting results, but if it was modified, i. e., using one-half c.c. of the culture as inoculum in the broth test, he obtained consistent results. However, it is noteworthy that his cultures meeting this condition of purity, rapidly lost their power to oxidize ammonia. His explanation of this fact (physiological degeneration from growing on a solid medium), seems to the present writer wholly inadequate.

He describes briefly three forms which were eliminated with some

difficulty from his cultures.

Fred and Davenport (17) studied the effects of organic matter on a nitrate former which they isolated by means of dilutions and plating on washed agar. Nährstoff-Heyden solution was inoculated with one-half c.c. of culture and if it remained sterile after two weeks incubation, the culture was considered pure. These investigators say that the nitrate-forming organism will remain alive for two to six weeks and perhaps longer in 1 percent Nährstoff-Heyden, gelatin, peptone, casein, yeast water, milk or distilled water; but they found that the organism dies very rapidly in 1 percent beef extract.

Gowda (22) was unable to obtain consistent results with the broth test. The cultures, which were sterile at first, were either found to be contaminated later or they would not nitrify. Five organisms, two bacteria and three Actinomyces, which were more or less constant contaminators, are described. Some physiological studies are also reported.

Loew (32, 33) in 1891 discussed the chemistry of the nitrifying process. He concluded that the following equations probably represent the

transformations of nitrite formation and carbon reduction:

1.
$$2NH_3 + 20_2 = 2HNO_2 + 4H$$

2.
$$CO_2 + 4H = H_2O + HCHO$$

The formaldehyde could be used directly or polymerized to one of the higher carbohydrates, and then be assimilated.

Meyerhof (36), in a series of three papers, reports his studies on the respiration of nitrifying bacteria. His organisms were obtained from Omeliansky. Those interested in the physiology of these organisms will find these papers very interesting. This phase of the subject is also well summarized by Kostytschew (28) and Buchanan and Fulmer (9).

PRELIMINARY TESTS

The object of these tests was to isolate in pure culture some of the nitrifying organisms,

Τ.

A slightly modified Omeliansky solution was prepared, having the following composition: $(NH_4)_2SO_4$, 1 gram; K_2KPO_4 , 1 gram; NaC1, 2 grams; MgSO₄, 0.5 gram; Fe₂(SO₄)₃, trace; MnSO₄, trace; H₂O, 1 liter; MgCO₃, excess. This is Medium 1. The MgCO₃ was sterilized separately as a suspension and added with a sterile pipette. 500 c.c. Erlenmeyer flasks were used in all of these experiments with 100 c.c. of culture solution.

A few grams of Carrington loam were used as the inoculum and the culture incubated for two weeks. At this time a fairly strong nitrite reaction seemed to indicate that there were enough nitrifiers present to isolate.

Fifteen grams of washed agar were added to a liter of Medium 1, in which 0.5 gram K₂CO₃ was substituted for the MgCO₃. Plates were poured in the usual way. A few strands of sterile glass wool were dipped in the culture and placed on the surface of the plates to see if colonies would form and make it easier to locate them.

In 5 to 7 days colonies appeared all along the glass hairs. They were chiefly yellowish-brown, round or oval, some flat and others slightly raised in the center.

Several of these were picked out with a micropipette and inoculated into Medium 1. After shaking one-half c.c. was inoculated into nutrient broth of the following composition: Beef-extract, 3 grams; peptone, 7 grams; K₂CO₃, 0.5 gram; H₂O, 1 liter; pH, 6.8. Distilled water only was used in these experiments.

All cultures showed oxidation and all showed growth in broth.

H

It was evident from Test I that there were enough organisms present in the cultures to isolate, but the colonies were too numerous and close together to allow isolation of a single species. In view of this fact, plates were prepared in the following manner:

Solutions A, B, and C, modifications of those used by Gibbs (19) were

prepared. They had the following composition:

A. K₂HPO₄, 1.5 gram per 100 c.c.

B. (NH₄)₂SO₄, 0.75 gram MgSO₄, 0.75 gram Fe₂(SO₄)₃, trace MnSO₄, trace H₂O, 100 e.c.

C. NaC1, 3.0 gram Na₂CO₃, 1.0 gram H₂O, 100 c.c.

These solutions were sterilized separately and added to the plates when pouring the agar, 1 c.c. of each solution per plate. The agar used was one and one-half percent washed agar in distilled water, about 10 c.c. be-

ing used per plate. The inoculum, 1 c.c. of a dilution of one of the cultures, was mixed with the agar by rotating the plates before the agar was allowed to set. They were incubated under a bell jar to check evaporation, and examined from time to time with the microscope.

Microscopic colonies appeared in 10 days. Two kinds were chiefly in evidence. These were (1) spreading, slightly yellow without any definite form, always on the surface; (2) subsurface, oblong, clearly granular, yellowish-brown. The surface colonies were easily transferred with the micropipette (a modification of Barbers apparatus (2), but the subsurface colonies were difficult to remove. However, a number of each type were transferred to Medium 1 and tests made in broth as described in Test 1. All flasks showed oxidation and all broth tubes became cloudy.

Two species of Actinomyces were removed from one of these plates and cultivated on nutrient agar, a medium made by adding 15 grams of agar to one liter of nutrient broth. These cultures were replated and kept in the refrigerator until later. They will be called Actinomyces 200 and Actinomyces 300, respectively.

III.

Having failed to obtain pure cultures with washed agar, it was decided to try isolation with silica gel plates. These were prepared by the method outlined by Waksman and Carey (53), being dialyzed, however, with distilled water until free from chlorides and allowed to dry two or three days before adding the nutrient salts. These salts were supplied by adding 1 c.c. of each of solutions A, B and C of Test II to each plate. After allowing the plates to dry again under a cover to keep out the dust, they were carefully flamed and covered with sterile covers. Inoculations were made with sterile pipettes, one-half c.c. of a suspension of organisms being added to the center of the plate and allowing it to spread.

Colonies developed somewhat more slowly on these plates than on washed agar, but they were about the same in form and size. In all the first transfers of these colonies oxidation occurred and growth took place in broth.

One plate after nearly one month's incubation showed several quite uniform colonies. They were evoid, raised in the center, granular as seen with the high power lens, and rather dark brown. These were easily transferred with a micropipette and twelve flasks of Medium 1 were inoculated. All of these cultures showed growth in broth in one week. The oxidation of ammonium sulfate was somewhat slower than in previous tests. At the end of 10 days it was thought well to test these cultures again with nutrient broth, Accordingly, one-half c.c. from each flask was transferred to broth tubes. Eight tubes showed rapid growth, but the other four remained perfeetly clear. After several weeks these cultures were again tested and this time rapid growth occurred in the broth. By this test, then, these four cultures were at first impure, then pure, and finally impure again, Nutrient agar plates were poured and inoculated from a dilution of culture number 8, one of the four cultures just mentioned. Only one type of organism developed. The surface colonies were round, white by reflected light and light blue by transmitted light. The subsurface colones were ovoid, yellowish-brown, and granular as seen with the high power dry lens. The organism was a coccus and is called coccus 800 in this paper.

EXPERIMENTAL

Before presenting the results of these experiments a short discussion

of the problem will be given.

From the brief review of the subject given earlier, certain facts stand out rather prominently. First, the so-called contaminators have been noted by all students of the subject. These organisms have persisted in dilution tests almost indefintely, in fact the Franklands (16) are the only investigators who believe they obtained pure cultures by this method and they carried on their studies for two years. Winogradsky found it impossible to eliminate the last of these organisms without plating. Why do these organisms persist in mineral solutions?

Second, the broth test has not given consistent results. If Gibbs' (19) contention is correct that at least one-half c.c. of the culture must be transferred to make the test reliable, then all previous work must be unreliable, for no one used such large inoculations. Gowda (22) could not obtain consistent results with this test even when he used one-half c.c. and it is no less significant that the cultures of Gibbs, which met his criterion of purity, in most cases lost their power to oxidize ammonia as well. In Test II just discussed, the cultures were first impure, later pure and finally impure again by this test.

Third, by what energy do the contaminating forms continue to function in a mineral medium? One would infer that they multiply or it should be a rather simple matter to eliminate them from a culture by the dilution method. There is only one plentiful supply of energy in these solutions, namely, ammonium compounds. It is hardly likely that the true nitrifiers could reduce enough carbon, resynthesize it, and make it available to keep the contaminating organisms not only alive but multiplying so rap-

idly that they cannot be eliminated by dilution methods.

The last paragraph, however, contains an assumption, for no one, as far as known, has proved that contaminating forms actually multiply in mineral solutions. To answer this question, the following tests were made.

EXPERIMENT 1

(a) A flask of Medium 1 was inoculated with 1 c.c. of a culture which showed rapid oxidation of ammonia and was impure by the broth test. Counts were made by means of nutrient agar plates at weekly intervals. These are the results:

Age wh	en	Nun	nber
counted		per	c.c.
0			,600
1 week		,366	
2 weeks			,000
3 weeks			,000
	less	tha	
8 weeks		10	,000

These results show that there was a rapid increase in numbers the first week, followed by an irregular falling off. The data are too meager to per-

¹See also Waksman (54) page 69.

mit of any general conclusions, but there is an interesting indication shown.

(b) Would a contaminating organism growing on nutrient agar multiply when placed in a mineral solution? Coccus 800 was chosen in the attempt to answer this question.

A flask of Medium 1 was prepared in the usual way and inoculated with a needle from an agar slant. Counts were made at the time of inoculation and at weekly intervals. The following are the results:

	ge who	Numbers per c.c.
0		133,300
		Less than
•1	week	1,000
		Less than
	weeks	100
9	weeks	145,000

The organisms died off rapidly in this culture, more than 99.24 percent dying off the first week and more than 99.92 percent had died by the end of two weeks. Counts were not made again until the end of 8 weeks, at which time an increase in numbers had occurred. Evedintly there was an adaptation taking place in this solution. At the end of 11 weeks nitrites appeared in the solution.

The inoculation was very large in this case. If a small inoculum had been used, the results would have been different. It is possible that one-half c.c. could be withdrawn for the broth test and no organisms be transferred. Such a condition would account for the results noted in Test III.

(c) Would it be possible to prevent the rapid dying off noted in the last experiment? It was thought probable that an organic carbon source would be more easily utilized and reduce the high death rate.

A flask of Medium 1 was prepared in the usual way and made up to 0.25 percent dextrose. Two colonies from a plate used in counting in Experiment 1, (a) were mixed with the needle and a small portion transferred to the flask. Counts were then made to determine the effects on multiplication. The results follow:

Age when	Organisms
counted	per c.c.
0	136,000
1 week	4,300,000
2 weeks	54,650,000
3 weeks	167,665,000

The last plates were counted when the culture was 4 weeks old. The culture gave a very strong test for nitrites at this time and when analyzed a few weeks later contained 2.252 p.p.m. of nitrite nitrogen. These organisms had developed on a plate of nutrient agar, the medium recommended for tests of purity¹, for one week and when transferred to Medium 1 with 0.25 percent dextrose, had produced oxidation. This was not a pure cul-

¹See Waksman (54) page 69.

ture, but the fact that it grew on nutrient agar, developed colonies, and later produced oxidation showed that soluble organic matter was not toxic

to these organisms.

Several flasks of Medium 1 were prepared and made up to 0.25 percent dextrose. They were then inoculated with cultures from nutrient broth and nutrient agar which had been obtained from silica gel or washed agar plates. In some cases the oxidation was somewhat slower than in the case just given, but in every instance oxidation of ammonium sulfate took place.

An Actinomyces developed on the plates used in counting. This organism was isolated and studied later. It is called Actinomyces 400 in

this paper.

One of the broth tubes showed a peculiar growth. Small oil-like globules formed around the surface of the tube. A similar growth was noticed by Gowda (22). It was found that two organisms were present in the tube, one, an Actinomyces, and the other an ovoid organism called Bacterium 500 in this paper.

EXPERIMENT 2

Upon examining some silica gel plates which had been kept under bell jars for three months, some white colonies of Actinomyces were noticed. (Plate I.) The colonies closely resembled each other so it was thought probable that they were the same organism. A few threads were carefully removed from the surface of one of the colonies to nutrient agar. After growth occurred, the organism was replated to insure a pure culture and was then used in the following experiment. It is called Actinomyces 600 in this paper.

Six flasks of Medium 1 were prepared in the usual way. These were inoculated with a needle from an agar slant, incubated at room tempera-

ture for 38 days and analyzed for nitrites.

Table I gives the results.

This organism grew well on nutrient agar and when transferred to Medium 1 with or without dextrose it was able to oxidize ammonium sulfate. The carbohydrate evidently stimulated growth, as an examination of the flasks showed the growth to be roughly proportional to the dextrose content. This was not the case with oxidation, however, for there was little difference between cultures 2 and 3.

These cultures were tested for nitrates as follows: 10 c.c. of the culture was withdrawn, treated with a few crystals of urea and 5 c.c. of dil. $\rm H_2SO_4$. When the reaction was complete the absence of nitrite was demonstrated by the sulphanilic acid and alpha naphthylamine test. All the cultures showed the presence of nitrates with the diphenylamine test. Can the organism utilize nitrite nitrogen? It was decided to test this culture to learn if this was the case. Accordingly a medium was prepared having the following composition:

NaNO,		۰	٠		٠	۰		۰	۰	۰											1	.0		g	ra	m	ı
Na ₂ CO ₃		۰	٠					0			۰	۰									1	.0		g	ra	m	Ĺ
K ₂ HPO																											
NaC1																											
$MgSO_4$		۰		0	4			0	۰	٠	٠	۰	۰	۰	0			۰		0	0	.3		g'l	ra	m	ı
$Fe_2(SO_2)$	1));	3												٠	۰	0	۰	٠		۰			tı	ra	c€	,
MnSO ₄		l B	۰	a		۰	0													۰				tı	ra	ce	b
HO																					1	0	M		C	C	

This is called Medium 2 in this paper. 100 c.c. portions were placed in 500 c.c. Erlenmeyer flasks and sterilized. The dextrose treatments were added with a sterile pipette after cooling. After 38 days the cultures were analyzed for nitrates. The following method was used.

The culture was treated with a few crystals of urea and then 25 c.e. dil. $\rm H_2SO_4$. The absence of nitrites was shown by the sulphanilic acid alpha naphthylamine test. A small portion of silver sulfate was then added to precipitate the chlorides and sufficient calcium hydroxid to neutralize the acidity. The cultures were then filtered and an aliquot taken and analyzed by the phenoldisulphonic acid method. The results are given in Table II.

The checks contained only a trace of nitrate nitrogen, which was somewhat unusual, as seen by some of the later experiments.

The growth was about the same as that with ammonium sulfate and

roughly in proportion to the dextrose content.

The case of 1a and 1b is interesting. The growth was plainly visible on the surface of the solution. There was very little organic matter present in the medium, for only the best chemicals were used and the water was distilled from a dichromate solution. While the oxidation was slow, it was none the less definite.

TABLE I

The Effect of Dextrose on Oxidation of Ammonia by Actinomyces 600.

Number	Percent dextrose	Nitrite N. p. p. m.
Check	0.00	trace
Check	0.00	trace
1a	0.00	0.94
1b	0.00	1.34
2a	0.10	6.35
2b	0.10	5.05
3a	0.25	3.16
3b	0.25	10.55

EXPERIMENT 3

In Experiment 1 a culture was mentioned which showed butter-like globules around the surface when grown in broth. One of these globules was removed to a dilution flask shaken and some plates made with nutrient agar. Only one type colony appeared. These were usually round, gray and shallow. The organism was ovoid and was, as a rule, in chains of 2 to 6 cells. There was another organism in the broth tube, but I did not succeed in isolating it at this time. The ovoid organism was replated to insure a pure culture and used in the following tests. It will be called Bacterium 500 in this paper.

In Preliminary Test II an organism called Actinomyces 300 was men-

tioned. It, too, was used in these tests.

Flasks of Medium 1 and Medium 2 were prepared in the usual way and made up to 0.25 percent dextrose, sterile checks being made at the same time. Table III shows the results after 62 days.

No growth occurred in any of the nitrite flasks so it was clear that

these organisms could not use this source of nitrogen, at least under the conditions of this experiment.

TABLE II
The Effect of Dextrose on the Oxidation of NaNO₂
by Actinomyces 600.

Number	Dextrose	Nitrate N. p. p. m.
Check	none	trace
Check	none	trace
1a	none	1.66
1b	none	1.25
2a	0.10	1.20
2b	0.10	1.71
3a	.25	1.20
3b	.25	1.53

TABLE III

The Oxidation of Ammonium Sulfate by Actinomyces 300 and Bacterium 500 in the Presence of Dextrose.

	Nitrite
Organism	Nitrogen p. p. m.
Check	trace
Check	trace
Bact. 500	0.88
Bact. 500	1.49
A. 300	1.00
A. 300	1.00

EXPERIMENT 4

In Experiment 1 an Actinomyces was mentioned which is called Actinomyces 400 in this paper . When this organism is grown in a medium containing dextrose it excretes a pigment which appears pink at first, but turns brown if sufficient dextrose is present. The depth of color seems to be in proportion to the amount of dextrose present. It was found in qualitative tests made in Experiment 1 with Actinomyces 400 that the duplicates did not agree. This experiment was outlined to try to find out if this organism would oxidize nitrogen in sufficient amounts to be determined quantitatively. Number 1 and Number 4 were inoculated with growth from the surface of a culture growing in Medium 1. Number 2 was inoculated with organisms from a slant of dextrose agar prepared by substituting 0.5 gram of K_2CO_3 for the MgCO₃ of Medium 1 and adding 10 grams of dextrose and 15 grams of washed agar per liter. Table IV gives the results after 71 days.

This table shows that the source of the inoculum had no effect and that the higher dextrose content gave much the highest oxidation. It should be mentioned that these cultures were clarified with G Elf black before the nitrites were determined, as a pink pigment seriously interferes with the determination. They are easily clarified by shaking with a small portion of G Elf black and then filtering.

TABLE IV
Effects of Dextrose on Oxidation of Ammonium
Sulfate by Actinomyces 400.

Number	Dextrose percent	Nitrite N. p. p. m.
Check	0.0	trace
Check	0.0	trace
1	.01	1.687
1	.01	1.322
2	.01	1.602
2	.01	1.383
3	0.25	12.160

EXPERIMENT 5

This was outlined to learn which of the three organisms so far not tested would grow in Medium 2 when 0.25 percent dextrose is added. Culture flasks were prepared as outlined in Experiment 2. It was found that Actinomyces 400 and Coccus 800 made rapid growth, but Actinomyces 200 did not grow at all. Actinomyces 400 produced a pigment similar in every way to that produced in Medium 1 with dextrose added. Coccus 800 produced a slimy mass of growth covering the bottom of the flask. Actinomyces 400 and Coccus 800 both gave positive tests for nitrates, but no quantitative determinations were made.

EXPERIMENT 5

In the first cultures of Coccus 800 in Experiment 1, the duplicates did not agree. In one flask there was rapid oxidation, while in the other it was slow. It was decided to test several cultures of this organism to learn whether low concentrations of certain organic compounds would stimulate its activity. Several flasks of Medium 1 were prepared in the usual way and sterilized. The various organic constituents were then added from suitable solutions with a sterile pipette.

In order to have the inoculum equal in all flasks, a suspension of the organism was made in a flask of sterile medium and inoculatons made with sterile 1 c.c. pipettes. Counts were made to determine the number introduced into each flask. This was found to be 64,500,000, which is a very large inoculum.

Table V shows the treatments and results after 120 days incubation at room temperature in the dark.

This table shows that very small amounts of peptone stimulated exidation, but dextrose depressed it. Dextrose and peptone together had about the same effect as peptone alone.

The nitrite added as shown in the last part of the table, was equal to 0.01 c.c. of Medium 2 per 100 c.c. of culture. This is equal to 0.002 p.p.m. nitrite nitrogen, an amount too small to influence the results. Where no dextrose was present, the trace of nitrite gave the highest single oxidation, but where dextrose was present, the oxidation fell off quite regularly with the increase in dextrose. It should be emphasized that aeration was poor and no attempt was made to stimulate the oxidation of large amounts of ammonia. 500 c.c. Erlenmeyer flasks were used and 100 c.c. portions of Medium 1. The cultures were incubated in two large drawers of the desk.

TABLE V. THE EFFECTS OF DEXTROSE AND PEPTONE IN LOW CONCENTRATIONS ON THE NITRIFICATION OF AMMONIUM SULFATE BY COCCUS 800.

				Nitrite N.
	Percent	Percent	Nitrite	after 120
Flask No.	dextrose	peptone	added	days p. p. m.
Check	none	none	none	trace
Check	"	22	99	>>
1	22	"	22	0.271
1	"	"	27	0.261
2	.0025	59	29	0.182
2	"	27	27	0.167
3	.0050	27	"	0.188
3	.0050	22	99	0.188
4	.0100	"	29	0.222
4	.0100	27	99	0.213
2	.0200	"	29	0.188
$\frac{1}{2}$.0200	22	/33	0.207
6	none	.0025	22	0.264
6	27	.0025	39	0.315
7	27	.0050	33	0.420
7	77	.0050	99	0.471
8	22	.0100	. 22	0.319
8	77	.0100	"	0.420
9	,,	.0200	,,	0.541
9	77	.0200	27	0.313
. 10	.00125	.00125	,,	0.337
10	.00125	.00125	33	0.401
11	.00250	.00250	3)	0.371
11	.00250	.00250	33	
12		.00500	"	0.386
12 12	.00500	.00500	57	0.319
	.00500		"	0.325
13	.01000	.01000	"	0.271
13	.01000	.01000		0.343
14	none	none	trace	0.386
14		"	, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	0.672
15 .	.0025	"		0.146
15	.0025		3)	0.137
16	.0050	"	27	0.076
16	.0050	"	99	0.049
17	.0100	"	27	0.052
17	.0100	"	"	0.024
18	.0200	"	22	trace
18	.0200	99	22	0.052

The amounts oxidized are small, but none the less definite. It is evidently true that a basic solution will absorb small amounts of nitrites from the atmosphere as pointed out by Jordan and Richards (25). These investigators found that as much as 0.08 p.p.m. of nitrite nitrogen was absorbed in one of the flasks in 90 days. They say that larger amounts are at times absorbed, but give no figures. In the work of the writer, rather large amounts of nitrite nitrogen were absorbed in some of the later experiments, but in every case checks have been prepared and analyzed to insure a correct interpretation of the data secured.

EXPERIMENT 7

A. To test the influence of free carbon dioxid on oxidation of ammonia a number of flasks of Medium 1 were prepared in the usual way. One-hole

stoppers which would fit the flasks were fitted with freshly filled soda lime tubes. The flasks from which it was desired to keep the CO_2 of the air were closed with these stoppers, the cotton plugs being left in the lower part of the necks of the flasks. Paraffin was used to insure complete sealing of the flasks except, of course, the opening through the soda lime tubes. It was found necessary to incubate the CO_2 free cultures in the open laboratory since they were too high for the incubator. This might have made a slight difference in temperature. Otherwise the conditions were alike for all cultures. They were incubated 57 days. The rsults are recorded in Table VI.

In most cases the nitrite reaction was stronger in the cultures than in the checks, but it was not thought worth while to try to record the differences, which could not be measured quantitatively. In the case of Coccus 800, the carbon dioxid seems to be important in stopping the oxidation. Unfortunately, one of these cultures was spoiled by a contamination, so only one flask serves for comparison. The mold seemed to stop the growth entirely.

With Actinomyces 200 the absence of carbon dioxid influenced the oxidation slightly, but this was probably due to better aeration in the

flasks with free air.

Actinomyces 300 showed good growth in the flasks containing dextrose, but the organism was only beginning to utilize ammonia as a source of energy, apparently.

Actinomyces 400 was favorably affected by dextrose, but was not in-

fluenced very much by the absence of carbon dioxid.

Bacterium 500 was similar to Actinomyces 300 in all respects except that the growth was not so evident as in the case of the Actinomyces.

Actinomyces 600 was completely checked in the absence of both dextrose and carbon dioxid. Much of this was probably due to aeration. With dextrose the differences were not significant as the duplicates did not agree.

B. Since it was shown previously that only three of these organisms can grow in a nitrite solution, only these organisms were studied with this medium. The cultures were prepared in the usual manner, using Medium 2, and carbon dioxid was excluded with soda lime tubes as described above. The cultures were analyzed as follows: They were first filtered and treated with a few crystals of urea, shaken, and 5 c.c. of 1:1 sulfuric acid added. After being allowed to stand for some time, one c.c. was withdrawn from each flask and tested for the absence of nitrites. The cultures were then neutralized with NaOH and evaporated to about one-half volume. Two or three grams of sodium peroxide were then cautiously added and the flasks slowly heated. When almost dry, they were transferred to distilling flasks with 300 c.c. distilled water, treated with Devarda alloy and distilled into 1/50 normal acid. The excess acid was then titrated and the calculations made.

Perhaps the outstanding criticism of the data presented in Table VII is the lack of close agreement of the duplicate checks. The error, if there is any, is probably that it is too high. 600a agrees with the first of the checks and in this culture no growth was visible. With the exception of this culture, all showed growth and the table shows that oxidation occurred in every other case when compared to this check. Even assuming that the

TABLE VI. THE INFLUENCE OF FREE CO₂ ON THE OXIDATION OF AMMONIA TO NITRATES BY CERTAIN MICROORGANISMS.

o.10 recent cosent cose	nitrogen p. p. m. trace "" "" "" "" "" "" "" "" "" "" "" "" ""	contaminated, mold
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esent n sent n sent n n sent n n n sent sent n sent sent n sent sent n sent n sent n sent n sent sent n sent n sent n sent sent n sent n sent sent n sent sent n sent	trace " " 1.687 2.171 1.481 1.273 trace " " " " " " " "	
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"	1.140	
"	1.088	
	1.088	1
sent	trace	
"	"	
22	66	
esent	22	
99	29	
22	22	
22	22	
trone	0.545	
SCIII	*********	flash broken
22		
"	trace	1
22 22 22	22	l .
" esent	1.764	
esent	1.764 3.800	
" esent	1.764	contaminated,
		" trace

highest of the checks was the average for all flasks, there was still considerable oxidation produced by these organisms.

Strangely, the averages are higher where carbon dioxid was absent in all cases except one, namely, Coccus 800 without dextrose. This is extraordinary, too, because the aeration was much poorer in these flasks.

EXPERIMENT 8

It was found in Experiment 7 that the absence of organic matter and free CO_2 completely checked the oxidation of ammonia by Actinomyces 600. To test this result more closely, the following experiment was carried out.

TABLE VII. THE EFFECT OF CARBON DIOXID AND DEXTROSE ON THE OXIDATION OF NITRITES BY PURE CULTURE OF COCCUS 800, ACTINO-MYCES 400 AND ACTINOMYCES 600.

Organ	iem	Carbon		Nitrate	Average	Nitrate N.
Oigai	HOIM	dioxid	Dextrose	N. p. p. m.	Average	formed ¹
chec	k	present	dextrose	7.00	1	
chec	k	"	"	14.00	10.50	
Coccus	800a	present	absent	15.40		1
29	800b	~ <i>"</i>	"	19.60	17.50	7.00
22	800c	absent	"	14.00	Ī	1
22	800d	22	22	15.40	14.70	4.20
27	800e	present	present	19.60		
27	800f	27	"	12.60	16.10	5.60
22	800g	absent	27	22.40		İ
27	800h	27	22	16.80	19.60	9.10
A.	400a	present	absent	22.40		
22	400b	22	27	21.00	21.70	11.20
22	400c	absent	27	28.00		1
27	400d	22	22	19.60	23.80	13.30
27	400e	present	present	22.40		1
29	400f	22	- 22	16.80	19.60	9.10
92	400g	absent	22	lost		
22	400h	77	77	32.20	32.20	21.70
22	600a	present	absent	7.00		
22	600b	""	>>	14.00	10.50	0.00
22	600c	absent	27	21.00		
77	600d	22	27	14.00	17.50	7.00
22	600e	present	present	29.40		
27	600f	. 22	- 27	18.20	23.80	13.30
27	600g	absent	27	32.20		
22	600h	22	22	25.20	28.70	18.20

¹This column is obtained by subtracting the average of the checks from the average of the duplicates.

Fifty c.c. of Medium 1 were placed in each of eight 250 c.c. Erlenmeyer flasks. Various amounts of dextrose were added and the flasks autoclaved. After inoculation with a suspension of organisms, the cultures were incubated in a large dessicator over strong NaOH. After 46 days the cultures were analyzed for nitrites. The results are recorded in Table VIII.

The table indicates that there were nitrites in the medium, for there could not have been any absorption from the air. Sample 1 checks the re-

sults reported in Table VI. While growth was evident in both flasks, it was poor and no oxidation took place. There is little difference in the rate of oxidation in the presence of 0.10 percent and 0.25 percent dextrose. There was a slight difference in the amount of growth, however, more being present with the higher percentage of dextrose. The experiment clearly shows that this organism can utilize organic carbon and at the same time oxidize ammonium sulfate.

EXPERIMENT 9

A. To learn what concentration of dextrose would stimulate the greatest oxidation with Actinomyces 600, 28 flasks were prepared, 14 with Medium 1 and 14 with Medium 2, in the usual way. Unfortunately, the checks for the series with Medium 2 were lost, so this series was not analyzed. The cultures were incubated at 30° C. The results with ammonium sulfate after 19 days are given in Table IX. This experiment slightly modified was later repeated with other organisms previously mentioned.

TABLE VIII. THE EFFECTS OF THE ABSENCE OF FREE CO₂ ON THE NITRI-FICATION OF AMMONIUM SULFATE BY ACTINOMYCES 600.

Number	Percent dextrose	Nitrite N. p. p. m.	Average	Nitrite N. p. p. m formed
check check	none none	0.029 0.023	0.026	
1 1	27	0.013	0.019	-0.007
2 2	0.10 0.10	0.798 1.140	0.969	0.943
3	0.25 0.25	1.380 1.173	1.276	1.250

^{&#}x27;This column is obtained by subtracting the average of the checks from the average of the various duplicates.

The amount of growth as shown by the appearance of the flasks increased regularly with the increase of sugar from none to 0.1 percent. There was a decided break at this point, that is, the flask having 0.5 percent dextrose had a much greater increase in growth over the one having 0.1 percent than this culture had over the one having 0.01 percent dextrose. The increase in growth from 0.5 percent to 2 percent was quite gradual.

Flask 5a was quickly overrun with a mold the first few days. Then the mold gradually decreased and Actinomyces 600 began to grow rapidly. Comparing this with the duplicate, it seems that the organism prefers dextrose as a source of energy, but can use ammonium sulfate when the sugar becomes limited. The mold evidently used up the dextrose quite rapidly and then development ceased. Actinomyces 600 was apparently able to utilize the only other source of energy in the culture, ammonium sulfate.

With the higher concentrations of dextrose there was a mere trace of nitrite produced. The growth was very much denser, however, than with low concentrations of dextrose, forming a heavy mat of growth on the entire surface of the cultures.

TABLE IX. THE EFFECTS OF VARIOUS CONCENTRATIONS OF DEXTROSE ON THE OXIDATION OF AMMONIUM SULFATE BY ACTINOMYCES 600.

Number	Percent Dextrose	Nitrite nitrogen p. p. m.	Remarks
check check	none	0.00 0.00	
1a	0.000	0.176	
1b	0.000	0.216	
2a	0.001	0.195	
2b	0.001	0.222	
3a	0.01	4.560	
3b	0.01	4.134	
4a	0.1	2.028	
4b	0.1	3.648	
5a	0.5	5.700	contaminated, mold
5b	0.5	trace	
6a 6b	1.0	trace	
7a	2.0	??	
7b	2.0	??	

The growth on the nitrite medium was similar to that on ammonium sulfate. There seems to be no difference in the utilization of nitrite nitrogen and ammonia nitrogen by this organism.

B. In Part A of this experiment, only a 19 days incubation period was employed. Would this organism oxidize ammonia in the presence of higher concentrations of dextrose if more time were allowed? To answer this question, the following tests were made: Cultures were prepared in the usual way, using Media 1 and 2. The cultures were incubated in the open laboratory for 85 days. This is mentioned merely as a possible explanation of the large amount of nitrites found in the checks. The results are given in Tables X and XI.

The checks in this series contained an unusual amount of nitrites. There are two possibilties which might explain this condition: (1) the cultures were incubated in the large laboratory where students were working and they might, therefore, have absorbed the nitrites from the air; (2) they might have been in the chemicals or the water. The writer has no explanation for it and was surprised to find such a large amount present when the analyses were made.

The oxidation in this series was slower than in the one reported in Table IX, except in the case of the higher dextrose concentrations. Here the long incubation period brought about oxidaton. The growth in general was in proportion to the dextrose content (see Plate II, Numbers 1, 2 and 3).

The growth in the nitrite cultures was similar to that with ammonium sulfate as shown in Plate II, 4, 5 and 6. These cultures were also incubated in the large laboratory as the others for 85 days. They were analyzed as outlined in Experiment 7, B. Table XI gives the results.

There is no agreement between the checks in this table. For this reason little weight can be given to the results. However, with 2 percent dextrose the oxidation is so large that it can hardly be due to error. The table

would seem to indicate an error in analysis, but the writer has not been able to find any errors there. Perhaps the most that can be said is that this organism grows as well with nitrite nitrogen as with ammonia and may bring about considerable oxidation under favorable conditions.

TABLE X. THE EFFECTS OF VARIOUS CONCENTRATIONS OF DEXTROSE ON THE OXIDATION OF AMMONIUM SULFATE BY ACTINOMYCES 600.

Number	Percent dextrose	Nitrate nitrogen p. p. m.	Average	Amount nitrified p. p. m.
check check	none	0.127 0.173	0.150	
1	"	0.300 0.316	0.308	0.158
2 2	0.01 0.01	0.475 0.621	0.548	0.398
3	0.05 0.05	1.140 0.949	1.044	0.894
4	0.10 0.10	1.200 1.034	1.117	0.967
5 5	1.00	2.459 1.754	2.106	1.956
6	2.00 2.00	2.353 2.363	2.358	2,208

TABLE XI. THE EFFECT OF VARIOUS AMOUNTS OF DEXTROSE ON THE OXIDATION OF NITRITES BY ACTINOMYCES 600.

Number	Percent dextrose	Nitrite nitrogen p. p. m.	Average	Amount nitrified p. p. m.
check check	none	16.24 10.64	13.44	
1	27	1.40 7.00	4.20	-9.24
2 2	0.01 0.01	8.96 12.88	10.92	-2.52
3 3	0.05 0.05	12.60 24.92	18.76	5.32
4 4	0.10 0.10	16.52 22.96	19.74	6.30
5 5	1.00 1.00	13.72 58.80	36,26	22.82
6	2.00 2.00	68.32 43.40	55.86	42.22

¹This column is obtained by subtracting the average of the checks from the average of the duplicates.

EXPERIMENT 10

In order to test the effects of various concentrations of dextrose on nitrification of ammonia by Actinomyces 200 and Actinomyces 300, the following experiment was carried out. Cultures were prepared in the usual way.

After inoculation with a suspension of the organisms the cultures were incubated at 30 degrees centigrade for 93 days. Table XII shows the results.

There was little oxidation in any case as shown by this table. The growth appeared to be in proportion to the amount of dextrose present, but was chiefly on the bottom of the flasks. The checks do not agree and show considerable nitrite content, especially considering that these cultures were incubated in a closed chamber at a constant temperature.

Unlike Actinomyces 600, these organisms did not show any nitrites where 1 and 2 percent dextrose was used. Furthermore, the oxidation was much lower than shown in other experiments with these organisms except in the absence of dextrose. In these cases, the highest results were secured with both organisms in this experient.

TABLE XII. THE EFFECTS OF VARIOUS CONCENTRATIONS OF DEXTROSE ON NITRIFICATION OF AMMONIUM SULFATE BY ACTINOMYCES 200 AND ACTINOMYCES 300.

Number	Percent dextrose	Nitrite N. p. p. m.	Average	N. nitrified p. p. m.1
check	0.00	0.025		
check	0.00	0.012	0.018	
A. 200 1	0.00	0.049		
" " 1	0.00	0.077	0.063	0.045
" " 2	0.01	0.050		
" " 2	0.01	0.025	0.038	0.019
" " 3	0.05	0.049		
" " 3	0.05	0.025	0.037	0.018
" " 4	0.10	0.016		
27 27 4	0.10	trace	0.016	-0.002
" " 5	1.00	trace	*******	
" " 5	1.00	"		
" " 6	2.00	27		1
" " 6	2.00	27	********	
A. 300 7	0.00	0.092		
" ' 7	0.00	0.039	0.065	0.047
22 27 8	0.01	0.061		
" " 8	0.01	0.035	0.048	0.030
" " 9	0.05	0.017		
" " 9	0.05	0.057	0.037	0.019
" " 10	0.10	0.015		
" " 10	0.10	0.011	0.013	0.006
" " 11	1.00	trace		
" " 11	1.00	29	******	
" " 12	2.00	trace		
" " 12	2.00	22		-

^{&#}x27;This column is obtained by subtracting the average of the checks from the average of the various duplicates.

EXPERIMENT 11

It was thought that probably these organisms would have either a beneficial or harmful effect on each other if grown together. To test this proposition, a number of cultures were prepared in the regular way. Suspensions of organisms were used for inoculation, 1 c.c. being used for each. Where two organisms were introduced, only one-half c.c. of the respective

suspensions was added, making the total inoculum about the same in all cases. The cultures were incubated in the open laboratory for 45 days. Several checks were prepared to try to learn what conditions favor absorption of nitrites from the air. These were treated as follows: Checks (a) and (b), Medium 1 without $MgCO_3$ in well stoppered flasks; (c) and (d), the same as (a) and (b), except $MgCO_3$ added; (e) and (f), Medium 1 without $MgCO_3$, plugged with cotton and left on the laboratory desk; (g) and (h), Medium 1 with $MgCO_3$, plugged with cotton and placed with the cultures; (i) and (j), Medium 1 with $MgCO_3$ and 0.10 percent dextrose, plugged with cotton and placed with the cultures. Table XIII gives the results after 45 days.

This series of checks is interesting. When well stoppered, no nitrites appeared in the flasks either with our without MgCO₃. Where only cotton plugs were used and no MgCO₃ added, 0.001 p.p.m. of nitrite nitrogen was absorbed, and similar flasks to which MgCO₃ was added 0.024 p.p.m. of nitrite nitrogen was absorbed. Dextrose did not affect the rate of absorption either with our without MgCO₃. It is seen from these tests, which are similar to those reported by Jordan and Richards (25) that great caution is essential in making qualitative tests as well as quantitative determina-

tions of nitrites in incubated cultures.

In all but one case, namely, Bact. 500 with C. 800, the dextrose cultures gave higher results than similar cultures without dextrose, and in this case the difference is small. Actinomyces 300 and Actinomyces 600 are benefited by growing together both with and without dextrose. These organisms gave the highest single oxidation. Bacterium 500, grown with Actinomyces 200, did not oxidize as rapidly as when grown alone; but this is not the case when it was grown with Actinomyces 300, where a higher oxidation occurred than either organisms produced when grown alone.

EXPERIMENT 12

In order to determine whether or not the six organisms described in this paper would nitrify ammonium sulfate in soil, the following experiment was carried out. Fifty gram portions of soil were weighed into 250 c.c. Erlenmeyer flasks and treated with 0.3 gram MgCO₃. They were then made up to optimum moisture and sterilized at 18 pounds pressure for three hours in the autoclave. 15 mgm. nitrogen as ammonium sulfate was then added to each flask. Half of the samples received 0.10 percent dextrose. Suspensions of the various organisms were used for inoculation.

The cultures were incubated at room temperature in the dark for 80 days. Sterile water was added every week to keep up the optimum moisture content, the amount needed being determined by weighing the flasks.

The results are recorded in Table XIV.

In all but one case there was higher oxidation where no dextrose was added. This is probably due to the use of dextrose for energy by the organisms. There is a considerable soluble organic matter in autoclaved soil which may account for the small amount of nitrogen oxidized in most cases. The greatest oxidation was brought about by Actinomyces 600 in the absence of dextrose. This organism also showed the greatest difference between the soil treated with dextrose and that not treated. This experiment shows clearly that the organisms described in this paper are able to nitrify ammonium sulfate in soil as well as in solution.

TABLE XIII. THE EFFECTS OF DEXTROSE ON CERTAIN NITRIFIERS WHEN GROWING ALONE OR TOGETHER.

Organisms	Percent dextrose	Nitrite N. p. p. m.	Average	Nitrite N. produced p. p. m.
check a	none	0.000	*******	
check b	99	0.000	***************************************	***************************************
check c	22	0.000	*******	********
check d	22	0.000		*****
check e	22	0.001		********
		0.001	0.001	
heck f			0.001	
check g	none	0.029		
check h	1	0.019	********	
heck i	0.10	0.024		
check j	0.10	0.025	0.024	
A. 200	0.00	0.023		
A. 200	0.00	0.026	0.024	0.000
A. 200	0.10	0.035		
A. 200	0.10	0.028	0.031	0.007
A. 200 A. 300	0.00	0.019		
			0.000	0.004
A. 200 A. 300	0.00	0.022	0.020	-0.004
A. 200 A. 300	0.10	0.036	0.004	0.030
A. 200 A. 300	0.10	0.032	0.034	0.010
A. 200 A. 400	0.00	0.029		
A. 200 A. 400	0.00	0.022	0.025	0.001
A. 200 A. 400	0.10	0.086	0.020	01002
A. 200 A. 400	0.10	0.100	0.093	0.069
			0.000	0.000
A. 200 Bact. 500	0.00	0.028		
A. 200 Bact. 500	0.00	0.034	0.031	0.007
A. 200 Bact. 500	0.10	0.037		
A. 200 Bact. 500	0.10	0.038	0.037	0.013
A. 200 A. 600	0.00	0.029		
L. 200 A. 600	0.00	0.022	0.025	0.001
A. 200 A. 600	0.10	0.238	0.0.00	0.001
			0.046	0.000
A. 200 A. 600	0.10	0.254	0.246	0.222
L. 200 C. 800	0.00	0.028		
a. 200 C. 800	0.00	0.029	0.028	0.004
A. 200 C. 800	0.10	0.035		
L. 200 C. 800	0.10	0.035	0.035	0.011
A. 300	0.00	0.036		
L. 300	0.00	0.040	0.038	0.014
			0.058	0.014
A. 300	0.10	0.054	0.050	0.000
L. 300	0.10	0.051	0.052	0.028
A. 300 A. 400	0.00	0.041		
A. 300 A. 400	0.00	0.041	0.041	0.017
L. 300 A. 400	0.10	0.262		
A. 300 A. 400	0.10	0.141	0.201	0.177
. 300 Bact. 500	0.00	0.112	01201	V.211
			0.110	0.000
A. 300 Baet. 500	0.00	0.109	0.110	0.086
. 300 Bact. 500	0.10	0.173	0.7	
300 Baet. 500	0.10	0.200	0.186	0.162
. 300 A. 600	0.00	0.181	0.177	0.153
. 300 A. 600	0.00	0.173		01200
. 300 A. 600	0.10	0.760		
A. 300 A. 600	0.10	0.950	0.855	0.001
			0.000	0.831
L. 300 C. 800	0.00	0.085		
L. 300 C. 800	0.00	0.081	0.083	0.059
L. 300 C. 800	0.10	0.158		
L. 300 C. 800	0.10	0.095	0.176	0.152

TABLE XIII (CONTINUED)

Organisms	Percent dextrose	Nitrite N. p. p. m.	Average	Nitrite N. produced p. p. m.1
A. 400	0.00	0.075		
A. 400	0.00	0.085	0.080	0.056
A. 400	0.10	0.223		
A. 400	0.10	0.271	0.247	0.223
A. 400 Bact. 500	0.00	0.100		
A. 400 Bact. 500	0.00	0.093	0.096	0.072
A. 400 B. 500	0.10	0.237		
A. 400 B. 500	0.10	0.223	0.230	0.206
A. 400 A. 600	0.00	0.126		
A. 400 A. 600	0.00	0.098	0.112	0.088
A. 400 A. 600	0.10	0.254		
A. 400 A. 600	0.10	0.271	0.262	0.238
A. 400 C. 800	0.00	0.100		
A. 400 C. 800	0.00	0.100	0.101	0.077
A. 400 C. 800	0.10	0.237		
A. 400 C. 800	0.10	0.223	0.230	0.206
B. 500	0.00	0.119		
B. 500	0.00	0.070	0.094	0.070
B. 500	0.10	0.095	1	
B. 500	0.10	0.115	0.105	0.081
B. 500 A. 600	0.00	0.136		
B. 500 A. 600	0.00	0.109	0.122	0.098
B. 500 A. 600	0.10	0.506		
B. 500 A. 600	0.10	0.400	0.453	0.429
B. 500 C. 800	0.00	0.115		
B. 500 C. 800	0.00	0.119	0.117	0.093
B. 500 C. 800	0.10	0.131		
B. 500 C. 800	0.10	0.088	0.109	0.085
A. 600	0.00	0.115		
A. 600	0.00	0.115		
A. 600	0.00	0.146	0.130	0.106
A. 600	0.10	0.292		
A. 600	0.10	0.343	0.317	0.293
A. 600 C. 800	0.00	0.152		
A. 600 C. 800	0.00	0.105	0.128	0.104
A. 600 C. 800	0.10	0.422		
A. 600 C. 800	0.10	0.543	0.482	0.458
C. 800	0.00	0.112		A - Marie and A
C. 800	0.00	0.103	0.107	0.083
d. 800	0.10	0.345		
2. 800	0.10	lost	0.345	0.321

¹This column is obtained by subtracting the average of the checks from the average of the various duplicates.

MORPHOLOGICAL AND CULTURAL CHARACTERISTICS

The morphological characteristics of actinomyces have been studied by several investigators, including Krainsky (29), Dreehsler (14), Waksman (52), and more recently by Orskov (41). All of these sources have been used for reference in these studies. The agar block as used by Orskov was found to be the most serviceable for studying the germination of spores and colony formation. The aerial mycelia may be studied either in the colony or by removing to a slide, as suggested by Waksman (54, pages 291-292), and staining with the ordinary laboratory stains.

The cultural characteristics were studied by inoculating various media and recording the description of the growth produced. This is similar to the methods of Conn (13) and Waksman (52). However, the media have been chosen somewhat arbitrarily in these studies and their value for characterizing growth is not known in all cases. This question can be settled only by a study of several known species.

Very few biochemical studies were made, owing to lack of time. Starch hydrolysis and nitrate reduction were studied in solution and on agar plates. The other reactions have been recorded with the descriptions of growth.

TABLE XIV. THE EFFECTS OF 0.10 PERCENT DEXTROSE ON NITRIFICATION OF AMMONIUM SULFATE IN CARRINGTON LOAM BY CERTAIN PURE CULTURES.

Number	Percent	Nitrite	
Organism	Dextrose	N. p. p. m.	Average
Check	0.00	trace	
Check	0.00	22	
Check	0.10	22	
heck	0.10	77	
. 200	0.00	1.000	
A. "	0.00	0.760	0.880
A. "	0.10	0.158	
A. "	0.10	0.127	0.142
A. 300	0.00	0.060	
A. "	0.00	0.060	0.060
A. "	0.10	0.471	
4. "	0.10	0.375	0.423
A. 400	0.00	1.676	
A. "	0.00	1.627	1.651
A. "	0.10	0.413	
A. "	0.10	0.380	0.396
Bact. 500	0.00	1.117	
22 23	0.00	0.653	0.855
79 99	0.10	0.543	
27 27	0.10	0.032	0.287
A. 600	0.00	8.444	
4. "	0.00	4.222	6.333
1. "	0.10	0.471	
A. "	0.10	0.404	0.437
Coccus 800	0.00	1.359	
22 22	0.00	1.587	1.473
22 22	0.10	1.359	
27 22	0.10	1.186	1.272

CULTURE MEDIA

Unless otherwise stated, washed agar was used and the media were sterilized at 15 pounds pressure for 15 minutes. Distilled water was used in all media.

Medium 1. The modified Omeliansky's solution, which has been described in Preliminary Test 1. The only modification of this medium was the addition of various amounts of dextrose or starch.

Medium 2. This was described in Experiment 2. It was slightly modified by the addition of various amounts of dextrose.

Nutrient broth and nutrient agar. These were described in Prelimi-

nary Tests I and II.

Gelatin. This was made by dissolving 150 grams of Bacto-gelatine in one liter of distilled water and tubing.

Dextrose agar (Krainsky's). K4HPO2, 0.5 gram; asparagin, 0.5 gram; dextrose, 10 grams; agar, 15 grams; water, 1 liter; pH, 6.8-7.0. (Krainsky used 30 grams dextrose per liter.)

Calcium malate agar (Krainsky's). Calcium malate, 10 grams; NH.C1. 0.5 grams; K₂HPO₄, 0.5 grams; glycerin, 10 grams; agar, 15 grams; water,

1 liter: pH, 6.8-7.0.

Milk. Skimmed, tubed and autoclaved. Litmus milk. Milk with litmus added.

Ammonium sulfate dextrose agar. (NH₄) SO₄, 1 gram; K₅HPO₄, 1 gram; NaC1, 0.5 gram; MgSO₄, 0.5 gram; K₂CO₂, 0.5 gram; dextrose, 10

grams; agar, 15 grams; water, 1 liter; pH, 6.8-7.0.

Bean agar. 300 grams white beans were cooked thoroughly in 1 liter of water and wrung through cheese cloth into a solution containing 10 grams dextrose and 15 grams washed agar. The residue was discarded and the volume made up to 1500 c.c. The agar was tubed and sterilized.

Starch agar. 10 grams of potato starch were suspended in 800 c.c. water and boiled down to 500 c.c. Five hundred c.c. of Medium 1 having 0.25 gram K₂CO₃ substituted for the MgCO₃, and 15 grams agar were then

added, and the medium was completed as the others.

Cellulose agar 1. 500 c.c. of cellulose suspension prepared according to McBeth and Scales (35) were added to 500 c.c. of Medium 1 having 0.25 gram K₂CO₃ substituted for the MgCO₃. 15 grams agar were then added

and the medium completed as the others.

Cellulose agar 2. 500 c.c. of cellulose suspension were added to 500 c.c. of a medium having the following composition: K₂HPO₂, 1 gm.; MgSO₄, 0.5 gm.; KC1, 0.5 gm.; NaNO₃, 2 gms.; CaCO₃, 2 gms.; Fe₂(SO₄)₅, trace; water, 1 liter. This was then tubed and autoclaved.

Potato, carrot and turnip plugs. These were prepared in the usual

way and sterilized in the autoclave.

Onion extract agar, 250 grams white onions were cut up in 250 c.c. of water. They were cooked in the autoclave for 15 minutes at 10 pounds. This was filtered through a cloth, the volume made up to 500 c.c. and seven and one-half grams agar added. The medium was then tubed and com-

pleted as usual.

Humus agar. Peat was treated with one percent HC1 and after standing a short time washed free from chlorides, four percent NH₄OH was then added and after 24 hours standing with occasional stirring, was filtered. The filtrate was allowed to stand for a few days and 100 c.c. were withdrawn and made up to 1 liter with distilled water. 15 gms. of agar were added and dissolved. The medium was then tubed and sterilized. The medium contained 12.60 p.p.m. nitrogen in the form of ammonia¹.

^{&#}x27;The author is indebted to Mr. A. O. Alben for preparing the humus used in this medium.

A number of media were made up to study the growth characteristics with different sources of carbon. The following carbon compounds were used and added in one percent concentration: Mannitol, lactose, d-galactose, levulose, xylose, mannose and sucrose. The basic solution was the same for all and contained the following constituents per liter: NaNO₃, 2 gms.; K₂HPO₄, 1 gm.; MgSO₄, 0.5 gm.; KC1, 0.5 gm.; Fe₂(SO₄)₃, trace. After dissolving 15 gms. of agar in one liter of this solution the various carbon compounds were added and the media completed as usual.

DESCRIPTION OF SPECIES

Actinomyces 200

I. Morphology.

- Spirals.
 None noted; hyphae long, slender, with profuse branching.
- 2. Conidia.

 Spherical, forming chains which resemble streptococci. Usually four tubes formed when germinating.
- 3. Colonies: circular, see Plate V.

II. Cultural Characteristics.

- Medium 1 with 1 percent dextrose.
 Growth: Usually white discs on surface showing concentric rings.
 If MgCO₂ is excessive, often no surface growth.
- 2. Medium 2.
 Growth: None with or without dextrose.
- 3. Nutrient agar
 Growth: White in young cultures, turns to brownish-yellow.
 Wrinkled, having an oily appearance. Aerial mycelium, none.
- 4. Nutrient broth
 Growth: Usually on the bottom of tube. Aerial mycelium.
 Abundant on surface growth when any occurs.
 Pigment: None.
- Gelatin
 Growth: Very rapid at first, white to gray, slower after two or three days.
 Aerial mycelium: Few or none.
 Soluble pigment: Light yellow in liquefied portion.
 - Liquefaction: Rapid at first, but not complete in six weeks.
- 6. Dextrose agar
 Growth: Yellowish-gray, oily appearing, very slightly raised.

Most rapid in beginning.

Aerial mycelium: Develop slowly, white.

Pigment: None.

7. Calcium malate agar

Growth: Brownish-gray, very rapid at first, wrinkled.

Aerial mycelium: White, abundant.

Pigment: Yellowish-brown.

8. Milk

Growth: Slow; dark rim adhering to flask; on surface, yellowish

Aerial mycelium: Few.

Pigment: None at first, after digestion the liquid becomes light

9. Litmus milk

Same as milk except liquid becomes darker brown.

Reaction: Basic to litmus.

10. Tyrosine agar

Growth: Heavy pinkish-white, yellow globules of liquid abun-

dant on growth.

Aerial Mycelium: Abundant, light pink.

Pigment: None.

11. Ammonium sulfate dextrose agar

Growth: Abundant, yellowish growth.

Aerial mycelium: White, abundant.

Pigment: Light vellow.

12. Starch agar

Growth: Rapid, honey-like globules appear in 3 days. Surface

growth becomes dirty yellow in 7 to 10 days.

Aerial mycelium: Few, white, appearing around the edges of

growth.

Pigment: None. Hydrolysis: Rapid.

13. Bean agar

Growth: Very rapid, yellowish-brown, oily appearing.

Aerial mycelium: Begin around surface, rapidly covers all growth exposed, light pink.

Pigment: Yellow, medium finally becomes light brown.

14. Cellulose agar 1

Growth: White, subsurface growth abundant, surface flat, radiating

Aerial mycelium: Few, white.

Pigment: None.

15. Cellulose agar 2

Growth: Surface white, flat, radiating; subsurface, extensive.

Aerial mycelium: Few, white.

Pigment: None.

16. Potato plug

Growth: At first, white; later, dirty yellow to light brown, very

wrinkled, raised.

Aerial mycelium: Few, white.

Plug: Turns brown.

17. Carrot plug

Growth: Buff, slowly turns brown; very wrinkled.

Aerial mycelium: Appear in week to 10 days, white at first; turn light pink; abundant.

ngni pink; abundani

18. Turnip plug

Growth: Dirty yellow, barely raised, abundant.

Aerial mycelium: Light pink, become very abundant.

Plug: Brown.

19. Onion extract agar: No growth...

20. Humus agar

Growth: Slow, white, radiating from line of inoculation.

Aerial mycelium: Few, white. Pigment: None could be detected.

21. Mannitol agar

Growth: White, fuzzy, radiating; subsurface well developed.

After 1 month, faint pink, flat.

Aerial mycelium: Fine, quite numerous.

Pigment: None.

22. Lactose agar

Growth: Slow at first, well raised. Subsurface well developed.

Aerial mycelium: Good development, white at first, becomes

faint pink.

Pigment: Faint yellow.

23. d-Galactose agar

Growth: Very good, subsurface well developed. Aerial mycelium: White at first, becomes pink.

Pigment: Light vellow.

24. Levulose agar

Growth: Slow at first, well raised, profuse later.

Aerial mycelium: White at first, become pink and there appear many yellow globules of liquid which leave crater-like marks

on the surface of growth. Pigment: Light vellow.

25. Xylose agar

Growth: Slow at first, subsurface well developed.

Aerial mycelium: Pink, radiating from line of inoculation.

Pigment: Light yellow.

26. Mannose agar

Growth: Very good, subsurface well developed.

Aerial mycelium: White at first, turn pink, contain numerous yellow globules which leave crater-like marks on the surface of growth.

Pigment: Medium slowly darkens.

27. Sucrose agar

Growth: Good, subsurface well developed.

Aerial mycelium: White, fuzzy, turn pink. Covered with globules which leave crater-like marks on the surface of growth.

Pigment: Light yellow.

Actinomyces 300

I. Morphology

1. Spirals

Numerous, only one turn usually. Hyphae long, slender, crooked, profuse, branching, slightly tapering.

2. Conidia

Spherical or slightly ovoid; resemble streptococci. 2 or 4 tubes formed when germinating.

3. Colonies: Circular, see Plate VI.

II. Cultural Characteristics

1. Medium 1. With 0.1 percent dextrose.

Growth: Gray, flat colonies on surface; growth on bottom mostly.

Aerial mycelium: Gray.

Pigment: None, dirty yellow with higher concentrations of dextrose.

2. Medium 2

Growth: None with or without dextrose.

3. Nutrient agar

Growth: Good, raised center.

Aerial mycelium: Profuse, gray, covered with minute droplets

which leave crater-like marks.

Pigment: Medium becomes brown and finally deep purple.

4. Nutrient broth

Growth: On surface and bottom, irregular mass. Aerial mycelium: Gray, powdery, when present.

Pigment: Turns broth brown.

5. Gelatin

Growth: Rapid at first, then becomes slower.

Aerial mycelium: Brown.

Liquefaction: Rapid at first, then slow, not complete in six weeks.

6. Dextrose agar

Growth: White, rapid; subsurface well developed; becomes brown

in old cultures.

Aerial mycelium: Few, develop very slowly, gray.

Pigment: Medium slowly turns brown.

7. Calcium malate agar

Growth: Very rapid; pinkish-brown, wrinkled.

Aerial mycelium: Develop slowly, gray, dusty appearance.

Pigment: None, old cultures darken slightly.

8. Milk

Growth: Good, brown rim adhering to tube; mass on surface.

Aerial mycelium: Few, gray.

Pigment: Brown, medium looks like coffee and cream. Reaction: Acid to litmus; digestion of milk very slow.

9. Litmus milk

Growth: Same as in milk.

10. Tyrosine agar

Growth: Good, not raised; subsurface well developed.

Aerial mycelium: Gray, radiating, dusty.

Pigment: Medium slowly darkens.

11. Ammonium sulfate dextrose agar

Growth: White in young cultures, pinkish-brown in old; wrin-

kled; oily appearance; little or no subsurface growth.

Aerial mycelium: Gray; develop very slowly.

13. Starch agar

Growth: Rapid, flat; subsurface well developed.

Pigment: None. Hydrolysis: Rapid.

13. Bean agar

Growth: Very rapid; buff; under surface of growth red.

Aerial mycelium: Bluish-gray, abundant.

Pigment: Brown.

14. Cellulose agar 1

Growth: Good, flat, subsurface well developed.

Aerial mycelium: White, fuzzy.

Pigment: None.

15. Cellulose agar 2
Same as on cellulose agar 1.

16. Potato plug

Growth: Very rapid; wrinkled; gradually covering all the plug. Aerial mycelium: Profuse, white.

Plug: Black border around growth; whole plug black later.

17. Carrot plug

Growth: Very heavy buff to brown; spreads over surface rapidly, wrinkled.

Aerial mycelium: Light gray, dusty, few.

Plug: Darkened.

18. Turnip plug

Growth: Very rapid, spreads over all surface.

Aerial mycelium: Light gray, dusty.

Plug: Brown.

19. Onion extract agar

Growth: Rapid, buff, spreading over surface, produces strong

onion odor in 2 to 3 days.

Aerial mycelium: Blue-gray; profuse. Pigment: Brown; medium all colored.

20. Humus agar

Growth: Slow, but definite.

Aerial mycelium: White, few.

Pigment: None could be detected.

21. Mannitol agar

Growth: Very heavy.

Aerial mycelium: White at first, turns to blue-gray. Many liquid globules form, which leave crater-like marks on surface. Pigment: Medium turns first yellow, then light brown.

22. Lactose agar

Growth: Very heavy.

Aerial mycelium: White at first, turns to blue-gray. Many liquid globules form, which leave crater-like marks on the surface.

Pigment: Agar slowly darkens.

23. p-Galactose agar

Growth: Good.

Aerial mycelium: Gray at first, later, blue-gray; many liquid globules form which leave crater-like marks on surface.

Pigment: Medium turns yellow.

24. Levulose agar

Growth: Slow, well raised; subgrowth well developed.

Aerial mycelium: Blue-gray.

Pigment: Slightly darkened medium.

25. Xylose agar

Growth: Slow at first, good later; subsurface well developed.

Aerial mycelium: White, turns blue-gray; abundant.

Pigment: turns medium light brown.

26. Mannose agar

Growth: Good.

Aerial mycelium: White at first, turns to blue-gray; droplets of

liquid form which leave crater-like marks.

Pigment: Medium slowly darkens.

27. Sucrose agar

Growth: Very good.

Aerial mycelium: White at first, turns blue-gray, globules of

liquid form which leave crater-like marks on the surface.

Pigment: Medium slowly darkens.

Actinomyces 400

I. Morphology

1. Spirals

None noted; hyphae short, sharply tapering on most media.

2. Conidia

Form in long, thin threads; 0.4 micron by 0.8 micron; show granules when stained.

3. Colonies: Round or oblong. See Plate VII.

II. Cultural Characteristics

1. Medium 1. With 0.1 percent dextrose.

Growth: Spherical or flat colonies form on surface; some growth

on bottom.

Aerial mycelium: Gray.

Pigment: Pink, darkens with age of culture.

2. Medium 2. With 0.1 percent dextrose.

Growth: Very good on surface; some on bottom.

Aerial mycelium: Gray.

Pigment: Pink, darkens with age of culture.

3. Nutrient agar

Growth: Rapid; dull gray, slightly raised.

Aerial mycelium: Gray, globules of liquid form which leave

crater-like marks on surface.

Pigment: None.

4. Nutrient broth

Growth: Sponge-like growth on bottom; seldom any surface

growth.

Aerial mycelium: None, generally. Pigment: None, broth remains clear.

5. Gelatin

Growth: None.

6. Dextrose agar

Growth: Very slow; white spots appear after 6 days which turn to blue-gray, oily appearing masses.

Aerial mycelium: None.

Pigment: None.

7. Calcium malate agar

Growth: None.

8. Milk

Growth; Slow at first, ring forms on tube near surface.

Aerial mycelium: None noted.

Pigment: Milk becomes greenish when digestion is practically

complete.

Reaction: Acid.

9. Litmus milk

Growth: Same as in milk.
Aerial mycelium: None noted.

Pigment: After digestion, tubes become pink.

Reaction: Acid.

10. Tyrosine agar

Growth: Slow, bluish-white, after 4 days.

Aerial mycelium: Few, dusty, gray, only part of growth cov-

ered after 70 days.

Pigment: Medium turns brown.

11. Ammonium sulfate dextrose agar

Growth: Good: cream to white.

Aerial mycelium: White; numerous globules of liquid form.

leaving crater-like marks when they dry.

Pigment: None.

12. Starch agar

Growth: Good.

Acrial mycelium: White, fuzzy; numerous globules form, which leave crater-like marks on surface.

Pigment: None. Hydrolysis: Rapid.

13. Bean agar

Growth: None.

14. Cellulose agar 1

Growth: Small pin point nodules appear in 4 days; these gradually enlarge; the subsurface about equal to the surface growth. Aerial mycelium: White.

Pigment: None.

15. Cellulose agar 2

Growth: Pin point dots appear in 6 days; these gradually in-

crease in size.

Aerial mycelium: White.

Pigment: None.

16. Potato plug

Growth: Begins around margin after 2 weeks, white, gradually

increases.

Aerial mycelium: White, powdery.

Plug: Darkens.

17. Carrot plug

Growth: None.

18. Turnip plug

Growth: Slight after 2 weeks around edges of tube, gradually

increasing.

Aerial mycelium: White.

Pigment: None.

19. Onion agar

Growth: None.

20. Humus agar

Growth: White spots develop in 3 days, increase in size.

Aerial mycelium: White.

Pigment: None could be detected.

21. Mannitol agar

Growth: Slow, begins to be evident in week; raised, subsurface

well developed.

Aerial mycelium: Gray.

Pigment: Black; medium turns smoky.

22. Lactose agar

Growth: Evident in week; surface well raised; subsurface well

developed.

Pigment: None.

23. d-Galactose agar

Growth: Evident in 4 days, blue-gray.

Aerial mycelium: Gray; powdery, numerous small globules form.

leaving crater-like marks on the surface.

Pigment: Medium becomes pink, light purple, then dark, smoky.

24. Levulose agar Growth: None.

25. Xylose agar

Growth: Evident in 2 weeks, develops well.

Aerial mycelium: Gray; numerous globules leaving crater-like marks on surface.

Pigment: None.

26. Mannose agar

Growth: Well raised, dirty white growth after one week; little subsurface development.

Aerial mycelium: White.

Pigment: None.

27. Sucrose agar

Growth: Evident in 4 days; subsurface well developed.

Aerial mycelium: Blue gray.

Pigment: Medium becomes light purple under growth.

Actinomyces 600

I. Morphology

1. Spirals

None noted; hyphae usually thick, slightly tapering.

2. Conidia

Fine threads form which break up into rod shaped elements resembling bacilli; these are found to consist of small spherical spores. As a rule, one tube which branches profusely forms when germinating.

3. Colonies: Oblong, deep when young, later, round, massive with hypae extending slightly beyond the compact edge. See Plate X.

II. Cultural Characteristics

1. Medium 1

Growth: Small floating masses appear in 4 to 6 days; surface white, dusty.

Aerial mycelium: White, dusty.

1a. Medium 1 with 0.1 percent dextrose

Growth: Upper surface white; under surface, yellow; on bot-

tom and surface of liquid.

Aerial mycelium: White, dusty.

Pigment: Light yellow.

2. Medium 2

Growth: White, lace-like, floating, appears in 4 to 7 days.

Aerial mycelium: White.

Pigment: None.

2a. Medium 2 with 0.1 percent dextrose

Growth: White masses floating on surface, adhering to sides of flask; some on bottom.

Aerial mycelium: White, dusty.

Pigment: Light yellow.

3. Nutrient agar

Growth: Good, wrinkled, easily removed for there is scarcely any subsurface growth; yellow to brown.

Aerial mycelium: Few, white at first, turning to light pink.

Pigment: None noted.

4. Nutrient broth

Growth: Mass on surface; very little on bottom; very few subsurface mycelia; broth remains clear.

Aerial mycelium: White.

Pigment: None.

5. Gelatin

No growth.

6. Dextrose agar

Growth: Heavy, shallow, no subsurface growth noted.

Aerial mycelium: White, powdery; assumes a cream color in older cultures.

Pigment: None.

7. Calcium malate agar

Growth: Tiny specks appear in 2 weeks; become well raised.

pinkish; no subsurface growth.

Aerial mycelium: Gray at first; later, light pink.

Pigment: None.

8. Milk

Growth: Very slow; tiny white specks form in ring around tube in 2 weeks; gradually cover the surface, no coagulation noted.

9. Litmus milk

Growth: Begins after 2 weeks, gradually covers surface.

Aerial mycelium: White, dusty.

Pigment: Milk turns light green in 4 weeks; white layer on

bottom.
Reaction: Basic.

10. Tyrosine agar

Growth: Thin surface layer, very little subsurface development.

Aerial mycelium: White, become light pink.

Pigment: None.

11. Ammonium sulfate dextrose agar

Growth: Shallow surface layer at first, dirty yellow; raised with wart-like protrusions, in old cultures.

Aerial mycelium: White, dusty.

Pigment: None.

12. Starch agar

Growth: Poor, shallow surface growth.

Aerial mycelium: White, fuzzy.

Pigment: None. Hydrolysis: None.

13. Bean agar

Growth: Pin point specks appear in 12 days; grow quite rap-

idly, form well raised, pinkish growth. Aerial mycelium: Pink, dusty.

Pigment: Light yellow.

Cellulose agar 1

Growth: Growth in 4 days, shallow, white.

Aerial mycelium: White, fine.

Pigment: None.

Cellulose agar 2

Like the growth on cellulose agar 1.

Potato plug Growth: None.

17. Carrot plug

Growth: None.

Turnip plug

Growth: Small white specks adhering to tube near contact with plug in 7 days; slowly extend to water in bottom of tube, and after 3 weeks, attacks side of plug.

Aerial mycelium: White.

Plug: No change in 6 weeks.

19. Onion agar

Growth: None.

20. Humus agar

Growth: Good in 3 days.

Aerial mycelium: White.

Pigment: None detected: medium is black.

Mannitol agar 21.

Growth: Pin point specks appear in 4 days; become wrinkled,

well raised.

Aerial mycelium: Pink.

Pigment: None.

22. Lactose agar

Growth: Appears in 6 days as small speeks; becomes smooth;

surface with even edges.

Aerial mycelium: Powdery white with pink tint.

Pigment: None.

23. d-Galactose agar

Growth: Appears in 4 to 6 days; develops well.

Aerial mycelium: Whitish-pink, powdery.

Pigment: None.

24. Levulose agar

Growth: Appears in 7 days as small dots; develops well; be-

comes heavy, wrinkled.

Aerial mycelium: Light pink.

Pigment: None.

25. Xylose agar

Growth: Develops well after 10 days. Aerial mycelium: Light pink, powdery.

Pigment: None.

26. Mannose agar

Growth: Small specks appear in 4 days; then develop well; be-

come wrinkled.

Aerial mycelium: Light pink; powdery.

Pigment: None.

27. Sucrose agar

Growth: Appears in 4 days; develops rapidly; becomes very

heavy and wrinkled.

Aerial mycelium: Light pink, powdery.

Pigment: None.

Bacterium 500

I. Morphology

Form: Ovoid in stained preparations, more nearly a rod on agar

block. See Plate VIII.

Size: 1.4 micron by 2.0 to 2.5 microns in stained preparations; much larger when observed on agar block. Usually observed in chains of 2 to 6 cells or in groups. In stained preparations, resembles strings or bunches of sausages.

Motility: Motile with one flagellum, long, near pole; cells progress

like train of cars in hanging drop.

Staining reactions: Stains readily with ordinary stains; gram negative. Spore formation: None noted.

11. Cultural Characteristics

1. Medium 1 with 0.1 percent dextrose

Growth: Liquid slowly becomes slightly turbid; the ${\rm MgCO_3}$ becomes somewhat granular, like crumbs. No coloration, except with higher concentrations of dextrose.

2. Medium 2 with 0.1 percent dextrose Growth: None.

3. Nutrient agar

Growth: Colonies develop rapidly, pink; in old cultures the growth becomes almost black.

Medium: No change.

4. Nutrient broth

Growth: Very rapid, chiefly on bottom of tube, when disturbed, white flakes become dispersed in the liquid, the broth rapidly clouding.

5. Gelatin
No growth.

6. Dextrose agar

Growth: Good in 24 hours; brownish-white.

Medium: No change.

7. Calcium malate agar

Growth: Good in 24 hours; whitish-gray; this slowly turns brownish-pink.

Medium: No change.

8. Milk

Growth: Apparent in 24 hours on surface, in 4 weeks milk completely digested. Liquid yellow to brown.

Reaction: Basic.

9. Litmus milk

Growth: Same as in milk at beginning; white layer of liquid forms on bottom. As digestion proceeds, the liquid becomes light yellowish-brown, then finally assumes a purple tint.

Reaction: Basic.

10. Tyrosine agar

Growth: Honey-like globules form in 8 to 10 days; become flat, blue-gray.

11. Ammonium sulfate dextrose agar

Growth: Bluish-gray, honey-like globules.

Medium: No change.

12. Starch agar

Growth: Appears in 2 to 3 days, blue-gray.

Hydrolysis: Complete in 2 weeks.

13. Bean agar

Growth: Very rapid, covering line of inoculation in 15 hours,

buff, oily appearance.

Medium: Becomes light yellow.

- 14. Cellulose agar 1
 No growth.
- 15. Cellulose agar 2 No growth.

16. Potato plug

Growth: Honey-like globules appear in 2 days, this turns to buff, well raised, oily growth in 5 to 6 days. The growth darkens to a brown in 4 weeks.

Plug: Darkens.

17. Carrot plug

Growth: Grayish mucous-like in one tube, nothing in other. Repeated with same result. Inconclusive.

18. Turnip plug

Growth: Very rapid; buff, flat, rapidly covers all of plug. Plug: Brown,

19. Onion agar No growth.

20. Humus agar No growth.

21. Mannitol agar

Growth: Heavy buff and cream mottled, lobular; cream; turns

to buff and buff to dark pink with age.

Medium: No change.

22. Lactose agar

Growth: Same as 21, medium darkens slightly.

23. d-Galactose agar

Growth: Brownish gray; becomes mottled buff and gray.

Medium: Darkens.

24. Levulose agar

Growth: Same as 22, except that medium becomes light yellow.

25. Xylose agar

Growth: Very poor, blue-gray.

Medium: No change.

26. Mannose agar

Growth: Good brownish-gray at first, then very slow.

Medium: No change.

27. Sucrose agar

Growth: Heavy brownish-gray in 3 days; finally becomes dark

pink in 4 weeks.

Medium: Slightly darkened.

Coccus 800

I. Morphology

Form: Coccus, some cells slightly ovoid in rapidly growing cultures. Size: 0.6 to 0.8 micron average diameter. Usually form sheets on the slide, the cells being surrounded by a zoogleal mass. See Plate IX. Motility: Could not detect, nor could any flagella be found. Staining reactions: Stains easily with ordinary stains. Gram negative. Spore formation: None noted.

II. Cultural Characteristics

1. Medium 1 with 0.1 percent dextrose Growth: Chiefly on bottom, MgCO₃ slowly becomes granular crumbly.

2. Medium 2 with 0.1 percent dextrose Growth: On bottom, forming slimy mass.

3. Nutrient agar

Growth: Very rapid, white by reflected light, blue by transmitted. Subsurface colonies ovoid, granular, yellow to brown.

Medium: No change.

4. Nutrient broth

Growth: Slow, forming long, thin threads; if agitated, becomes cloudy.

5. Gelatin

Growth: None.

6. Dextrose agar

Growth: Very heavy blue-gray.

Medium: Unchanged.

7. Calcium malate agar

Growth: Very heavy bluish-white; after 24 days brown pin point spots appear on the surface of growth; these slowly enlarge. Medium: Becomes brown.

8. Milk

Growth: Rapid; becomes yellowish-brown when digested. Reaction: Basic

9. Litmus milk

Growth: Same as in milk; tubes become white on bottom, and after digestion, pink.

Reaction: Basic.

10. Tyrosine agar

Growth: Very heavy blue-gray, slowly turns to light brown. Medium: Becomes yellowish-brown.

11. Ammonium sulfate dextrose agar

Growth: Blue-gray; turns to light brown.

Medium: No change.

12. Starch agar

Growth: Rapid; white with bluish tint. Hydrolysis: Rapid.

13. Bean agar

Growth: Heavy, creamy layer on surface. Medium: Gradually turns brown.

- 14. Cellulose agar 1
 No growth.
- 15. Cellulose agar 2 No growth.
- 16. Potato plug Growth: Yellowish, creamy, spreads rapidly, gradually darkens. Plug: Becomes brown.
- 17. Carrot plug
 Growth: Creamy, spreading rapidly; turns water in tube turbid.
 Plug: One turned black; the other, brown.
- 18. Turnip plug
 Growth: Rapid, grayish-yellow; becomes light blue in 4 weeks.
 Plug: Light brown.
- 19. Onion agar Growth: None.

20. Humus agar Growth: None.

21. Mannitol agar

Growth: Very good, gray-white.

Medium: Light yellow, then light brown.

22. Lactose agar

Growth: Slow, bluish-gray, oily.

Medium: Light brown.

23. d-Galactose agar

Growth: Good, blue-gray.

Medium: First, yellow; then light brown.

24. Levulose agar

Growth: Good, blue-gray. Medium: Light yellow.

25. Xylose agar

Growth: Very slow; blue-gray.

Medium: No change.

26. Mannose agar

Growth: Good, bluish-white. Medium: Yellowish-brown.

27. Sucrose agar

Growth: Very rapid, blue-gray.

Medium: Light vellow.

SYSTEMATIC POSITION OF THE NITRIFIERS

The author believes that many of the soil organisms can utilize ammonia or nitrites as a source of energy under certain conditions. The organisms described by Winogradsky and others were in all probability very materially changed physiologically by being cultivated in purely mineral solutions for considerable periods. That pure cultures were obtained is not unlikely, but it is probable that either the majority of this group of organisms have not been isolated or their power to oxidize nitrogen compounds has not been ascertained.

In view of these considerations it is considered unwise to name the organisms described in this paper. The author is at present continuing these studes under a grant from the National Research Council and hopes to discuss this subject after more data are available. At the present time the data are too meager and conflicting to properly allocate the nitrifiers

to their proper place in the scheme of classification.

SUMMARY

Preliminary tests are described which were carried out in an attempt to isolate nitrifying organisms which would not grow in nutrient broth. These tests failed. All organisms isolated by means of silca gel or washed agar plates grew in nutrient broth.

Experiments were then conducted to learn if these organisms could multiply in a purely mineral solution. It was found that they multiplied rapidly when transferred from an enrichment culture to a fresh mineral solution, but if transferred from nutrient agar they died off rapidly. However, when a sufficiently large inoculum was used, the organisms survived and finally multiplied.

It was then decided to test the effects of a low concentration of dextrose on the multiplication of organims transferred from nutrient agar to a mineral medium containing dextrose and it was found that the organisms not only multiplied rapidly, but oxidized some ammonium sulfate in this mineral medium after four weeks. The next experiment confirmed these results and proved that these organisms can be cultivated in broth and can later nitrify ammonium sulfate when placed in a suitable medium. This shows that the broth test for purity of nitrifying cultures is worthless. While the organisms studied in this work grew in nutrient broth, it is not at all certain that all nitrifiers would grow under these conditions.

Several tests are reported showing the effects of various concentrations of dextrose on the nitrification process in solution and in soil. No attempt was made to stimulate a high rate of oxidation, but simply to demonstrate the ability of these organisms to nitrify ammonia and in some cases nitrites when placed in suitable environment. 100 c.c. portions of the medium in 500 c.c. Erlenmeyer flasks were used for the cultures.

Morphological and cultural characteristics of the six organisms isolated are given. These species grow well on ordinary laboratory media, some growing better on one medium and some on another. Three of the species grow well with nitrite as the source of nitrogen, but the others do not grow at all. Tests also show that these three organisms may oxidize either ammonium sulfate or nitrites, depending on the conditions. However, when the three organisms are cultivated in an ammonium sulfate medium, very little nitrate appears.

These experiments indicate that ammonium sulfate and nitrites are used for energy only, when more easily available sources of energy such as dextrose are lacking or limited. Further studies will be conducted on these organims during the next year.

CONCLUSIONS

- 1. Six species of nitrifying organisms were isolated and studied in pure culture. Of these four were Actinomyces and two were bacteria.
- 2. These organims grow well on most of the ordinary laboratory media, which shows that the broth test for purity of nitrifiers is worthless.
- 3. Tests are reported showing that these organims will nitrify ammonium sulfate in soil and solution.
- 4. Morphological and cultural studies are reported showing some of the characteristics of these organisms.
- 5. This work seems to indicate that ammonia and nitrites are used for energy by microorganisms only when other more easily available sources are limited or absent.

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PLATE I.

Four colonies of Actinomyces on silica gel, natural size. Organisms from these colonies were isolated but not studied owing to lack of time. In the square, a colony of Actinomyces 600 on silica gel from which this organism was isolated. Note the scars made by the micropipette when transfers were made. Enlarged about three diameters.



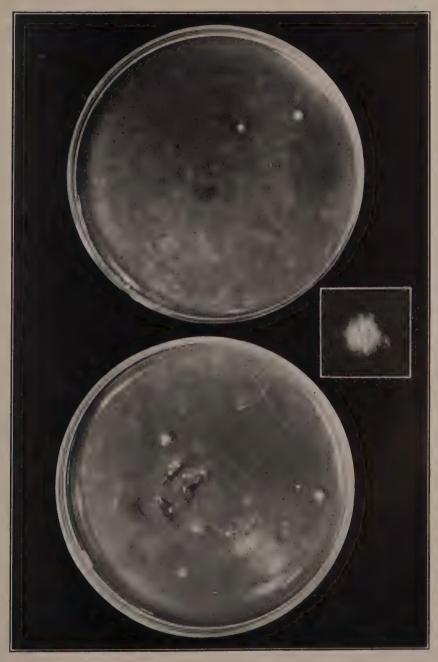


PLATE II.

Actinomyces 600. From left to right on the picture of (1) medium 1 without dextrose; (2) medium 1 with 0.10 percent dextrose; (3) medium 1 with 2.00 percent dextrose; (4) medium 2 without dextrose; (5) medium 2 with 0.10 percent dextrose; (6) medium 2 with 2.00 percent dextrose.



PLATE III.

Actinomyces 400. From left to right on the picture are (1) medium 1 with 0.10 percent dextrose; (2) medium 1 with 2.00 percent dextrose; (3) medium 2 with 0.10 percent dextrose; (4) medium 2 with 2.00 percent dextrose.



PLATE IV.

Culturs of Actinomyces on soil. From left to right on the picture they are (1) Actinomyces 200 on soil with ammonium sulfate; (2) Actinomyces 300 on soil with ammonium sulfate; (3) Actinomyces 400 on soil with ammonium sulfate; (4) Actinomyces 400 on soil with sodium nitrite; (5) Actinomyces 600 on soil with ammonium sulfate; (6) Actinomyces 600 on soil with sodium nitrite.





PLATE V.

Colonies of Actinomyces 200 on nutrient agar stained with gentian violet. Photographed with 16 mm, objective and number 10 ocular.

PLATE VI.

Colonies of Actinomyces 300 on nutrient agar stained with gentian violet. Photographed with 16 mm, objective and number 10 ocular,



PLATE V (above); Plate VI (below).

PLATE VII.

Colonies of Actinomyces 400 developing on nutrient agar. Not stained. Photographed with $16\ \mathrm{mm}$, objective and number $10\ \mathrm{ocular}$.

PLATE VIII.

Bacterium 500, a young culture, stained with gentian violet. Photographed with 1.9 mm. objective and number 10 ocular.



PLATE VII (above); PLATE VIII (below).

PLATE IX.

Coccus 800, a young culture, stained with gentian violet. Photographed with $1.9\,$ mm. objective and number 10 ocular.

PLATE X.

Colonies of Actinomyces 600 developing on nutrient agar. Not stained. Photographed with $16\ \mathrm{mm}$, objective and number $10\ \mathrm{ocular}$,



PLATE IX (above); PLATE X (below).



SOME FACTORS INFLUENCING THE PATHOGENICITY OF USTILAGO ZEAE (BECKM.) UNGER.

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Brefeld's (2) excellent contribution to the method of infection of corn by *Ustilago zeae* (Bekm.) Ung. added much to our understanding of this disease. However, he left much to be learned regarding the factors influencing infection, such as moisture, temperature, morphology of the host, and relative susceptibility of different varieties and strains of corn.

Progress in developing strains of corn highly resistant to smut, as an effective control measure, has been slow, due to unsatisfactory methods of measuring the comparative resistance of different strains of corn. The injection method quite generally adopted by various workers in the study of the reaction of Zeae mays L. to Ustilago zeae, excludes the necessity of penetration on the part of the pathogen and is, therefore, not comparable to natural infection. Since it is possible that resistance or susceptibility of different strains of corn to smut may be dependent upon the relative accessibility of the susceptible parts of the hosts to the pathogen, it seems essential in artificially determining the resistance or susceptibility of any particular strain, that the plants be exposed to uninjured attack by the fungus.

In order to develop a satisfactory method of artificially testing the relative susceptibility of different strains of corn to infection, experiments were devised, both in the greenhouse and the field, in which the development of the pathogen was followed and the relation of this development to the structures of the host plant was observed. These experiments were conducted under various conditions of humidity and temperature, to determine the influence of these latter factors upon infection. Studies were made, also, to determine the time, location, and extent of infection occurring naturally in the field.

Review of pertinent literature

The first significant study of the infection of corn by *Ustilago zeae* was made by Brefeld (2) which conclusively established the fact that corn smut is not a systemic disease. It seemed worth while to review Brefeld's work rather fully because of its importance in this problem. He studied the susceptibility of growing corn plants to infection by *Ustilago zeae*, beginning with the germinating kernel. He used five different varieties of corn in his experiments, but, finding no difference in their susceptibility, he reported the results of his work as a whole, irrespective of the variety of corn. In

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general, he used the following three methods in exposing the plants to infection: (1) impregnating the soil in which the corn was planted with sporidia, (2) spraying the plants or parts thereof by means of an atomizer with a suspension of the sporidia, and (3) dropping the sporidial suspension into the terminal leafspirals with a "Spritzflasche". In each case he used sporidia obtained from pure cultures grown in a nutrient solution. All corn for his experimental work was planted in boxes in the laboratory early in the spring and transplanted into the field later in the season.

In an experiment in which he planted soaked ungerminated corn in a fertilized soil impregnated with sporidia, one plant of 50 became infected and died within four weeks from the development of a smut boil on the

young stem just below the ground.

In a series of experiments in which he sprayed young seedlings with a sporidial suspension, he did not obtain much better results. In these tests, the corn was sown on the surface of the soil in boxes (50 kernels in a box). After the grain germinated, the young plants in four successive stages of growth were sprayed with the sporidial suspension and were kept covered with glass for two or three days. They were then exposed to the open air of the laboratory for two weeks and were subsequently transplanted to the field to mature. Of 200 plants in which the plumule with its surrounding coleoptile was just protruding from the kernel at the time they were sprayed, 16 became infected. Of 200 plants, sprayed when the plumule had grown slightly longer, but had not yet pierced the coleoptile, five became infected. One hundred plants sprayed just after the plumule had pierced the coleoptile remained non-infected. Similar experiments, conducted the following spring, in which seedlings, somewhat larger than those previously used, were sprayed with the sporidial suspension, likewise, gave negative results.

In experiments in which he dropped the sporidial suspension into the terminal leaf-spirals of the growing plants, he obtained very striking results. Of 100 plants about a foot tall thus treated, every plant became infected. These plants had been selected for infection studies because the terminal leaf-spirals formed by the unfolding leaves were particularly well developed. The corn had been planted in the laboratory in April; the plants were transplanted into the field in May and were treated about the middle of June. They were covered with straw mats for five days after being treated, in order to keep off the rain, and were then exposed to the open until mature.

With plants somewhat smaller, about one-half foot tall, Brefeld (2) found that the success of infection depended upon the extent to which the terminal leaf-spirals had developed. He noted that this characteristic of corn plants varied greatly in different varieties of corn and in different individuals of any one variety. He was unable to infect plants with poorly developed leaf-spirals, but succeeded in infecting all plants that had formed open leaf-spirals at this age. On the other hand, he was not very successful in infecting plants larger than one foot tall by dropping the suspension

^{*}Spritzflasche is defined in Muret-Sanders Enzyklopädisches Wörterbuch (Deutsch-English) as follows: "chm. washing-bottle." This is, no doubt, a washing-bottle as is used in chemical laboratories. It is not known whether the instrument used by Brefeld was so constructed.

of sporidia into the leaf-spirals even though these were well developed. Of 50 plants that he treated in this manner when about one and one-half feet tall, only six became infected. Plants that he treated when more than one and one-half feet tall remained entirely free from smut symptoms. He concluded that the sporidial suspension was no longer able to come in contact with penetrable tissue in these larger plants. Brefeld also obtained infection on the ears and on the adventitious brace-roots of corn plants. The ears were infected by dropping the sporidial suspensions into the distal ends with the "Spritzflasche" before the silk began to show or by exposing the young ovaries at the time of silking and spraying the suspension upon them with an atomizer. By both methods he obtained a rather high percentage of infection. He infected the adventitious roots by spraying the young tips with the sporidial suspension and wrapping them with parchment paper.

During his experimental work on infection, Brefeld (2) made a microscopic study of the penetration of the germ tube of the sporidia into the tissues of the host. He reported the observation of a few cases of penetration after spraying young seedlings with the sporidial suspension. These occurred only at the root-nodes. He found, however, that prolific penetration occurred when plants from one-half to one foot tall were treated by dropping the sporidial suspension into the terminal leaf-spirals. Within five days after treatment, the infecting-hyphae had penetrated the epidermis of the tender innermost leaves and the growing tips of the stem so that these tissues were literally perforated. By examining older plants that were similarly treated, he noted that as the tissues became more mature they became less liable to penetration. In some cases, he found that penetration had taken place, but that further development of the disease was arrested due to the rapid maturing of the host tissue that had been invaded.

In his account of the results of his experimental work, Brefeld (2) described in detail the first symptoms of corn smut as the disease manifests itself on the host and the subsequent development of these symptoms. He pointed out that the first symptom, especially on the leaves, is a discoloration of the infected area. The color of these areas varies from pale green to cream-yellow. The infected region may be uniformly discolored or irregularly mottled, streaked or even blotched due to the coalescence of the small initially infected spots. The discolored areas may become entirely bleached and even necrotic so that the tissues become disintegrated and torn. Also, they may become crinkled with wavy, knot-like roughenings, many of which later develop into small boils. In the latter case, a reddish-brown margin is often formed around the infected spots. On the other hand, the discolored areas may entirely disappear due to the death of the invading mycelium and subsequent restoration of normalcy in the host tissue.

From the results of his experiments, Brefeld (2) concluded that infection of corn by *Ustilago zeae* is possible on the leaves, on the stem, on the apical staminate inflorescences, on the axillary pistillate inflorescences and even on the adventitious roots. He concluded further that infection on any of these plant parts is possible only when viable sporidia come in contact with the host tissue that is sufficiently tender to permit the penetration of the germ tubes of these spores.

Hitchcock and Norton (8) and Clinton (4) confirmed the findings of Brefeld (2) as to the aerial and local nature of the infection by Ustilago zeae. Hitchcock and Norton (8) concluded further that infection may take place in any part of the plant where growing tissue is present, and at any time in its life, but scarcely ever before the plant has attained the height of three feet. This statement does not agree with the findings of Brefeld (2) since his best results were obtained with plants about one foot tall. Clinten (4) found also that mutilation of the plants, by detasseling about the time for the appearance of the tassels, increases the chances for infection. Piemeisel (13), likewise, concluded from the results of experiments that injury of the host increases the chance for infection. On the other hand, Mac-Millan (12), studying the conditions surrounding an epidemic of corn smut following hail in a small district near Greeley, Colorado, reported that, in spite of the fact that the corn plants showed abundant bruises and shattered leaves, the infection had taken place only at the leaf axils, not through wounds or bruises. His findings seem to be at variance, therefore, with those of Clinton (4) and Piemeisel (13).

Clinton (4), Arthur and Stuart (1), Piemeisel (13), and Potter and Melchers (14) made special study of the ecological factors influencing infection by Ustilago zeae. They noted that a moist or rich soil, thickly planted corn, maintaining a moist atmosphere between the plants or any other conditions that induce a vigorous growth and softness of tissues are conducive to the development of much smut. Arthur and Stuart (1) concluded that infection takes place largely during cloudy days or dewy nights though less smut often occurs in an especially rainy season than in a dry season. Potter and Melchers (14) also found that the disease is more prevalent in dry seasons than in wet seasons. Though Arthur and Stuart (1) and Piemeisel (13) reported more smut on early planted corn than on corn planted late in the season, Potter and Melchers (14) noted no appreciable difference in the amount of smut on early and late plantings. The above mentioned workers thus have pointed out certain ecological factors that affected the prevalence of corn smut though the influence of these factors is as yet not definitely understood.

Jones (11) was probably the first investigator who noted that susceptibility of corn to infection by Ustilago zeae is governed by hereditary factors which are capable of being segregated. His findings have been confirmed and enlarged upon by several subsequent workers. Potter and Melchers (14), for instance, secured strains of corn by inbreeding that showed great variation in susceptibility to infection. Hayes et al. (7), Garber and Quisenberry (5) and Immer (9) found that the prevailing point of infection on susceptible strains of corn seemed to be a strain characteristic. Immer and Christensen (10) noted that the factors determining resistance or susceptibility are transmitted in the same manner by both male and female gametes. Tisdale and Johnston (16) endeavored to find a means of testing corn seedlings for resistance to smut. They reported that strains of corn that showed resistance in the field also showed resistance in the greenhouse when inoculated during or after the three-leaf stage. Likewise susceptible strains in the field were equally susceptible when inoculated in the greenhouse. On the other hand, Griffiths (6) has found that selfed lines of corn that showed resistance to natural infection in the field were susceptible to corn smut when inoculated in the greenhouse by injecting

a sporidial suspension into the young tissues. It is evident, therefore, that, though it has been shown that susceptibility of corn to infection by *Ustilago zeae* is governed by inherent characteristics of the host, it is not known whether these characters are morphological or physiological.

Christensen and Stakman (3) in their studies with corn smut have found that the fungus is a group species comprising numerous physiological forms which vary in the virulence with which they attack different strains of corn. More recently (15) they have presented evidence that Ustilago zeae is heterothallic and that a difference in the degree of infection on the same strain or on different strains of corn is due to whether only one or both forms of the fungus have invaded the host. These findings make the study of resistance of corn to smut more complicated and present further need for an analysis of the relation of the morphology and the physiology of the corn plant to infection.

SMUT INFECTION OF REID'S YELLOW DENT ('ORN, STRAIN IODENT, NEAR AMES, IOWA, FOR THE YEARS 1923 AND 1927.

Observations during 1923

The occurrence of corn smut in 13 plots of corn in different fields near Ames. Iowa, was studied in 1923. Readings on the prevalence of the disease in these plots were made three times during the summer: July 20 to 25, August 5 to 10, and August 25 to 30. The results of this survey are shown in Tables I and II.

TABLE I. PREVALENCE	OF SMUT INFECTIO	N IN	13 PLOTS	OF REID'S
YELLOW DENT CORN	(STRAIN IODENT) N	EAR .	AMES, IOW	7A, 1923

No. Plants	Percent smut-infection				
examined	July 20-25	August 5-10	August 25-30		
800	5.8	10.2	29.3		
720	1.6	4.5	11.4		
320	4.0	9.7	10.0		
160	0.6	2.5	13.1		
1500	0.8	2,8	5.7		
630		2.2	10.3		
3030		2.6	5.4		
3150		5.7	8,3		
1650		4.3	6.9		
2025		3.4	6.7		
600		1.6	4.6		
2310		5.0	8.1		
360		2.7	6.6		
Total					
17,255	2.4	4.3	7.9		

Reference to Table I shows that 7.9 percent of the 17,255 plants that were examined were attacked by smut. At the time the first readings were made. July 20 to 25, the amount of smut was comparatively small, from 0.6 to 5.8 percent of the plants in the different plots or 2.4 percent of the 3,500 plants examined at this time. The second reading, August 5 to 10, showed that the percentage of smutted plants ranged from 1.6 to 10.2 percent in the several plots or 4.3 percent of the 17,255 plants that were examined. The third reading, taken August 25 to 30, showed that 4.6 to

29.3 percent of the plants in the different plots had become diseased by this time. A total of 7.9 percent of the 17,255 plants had been attacked. There was, therefore, a successive increase during the growing season of the number of corn plants showing infections with smut.

TABLE II. CORN-SMUT INFECTION ON VARIOUS ORGANS OF THE PLANTS AT THREE DIFFERENT STAGES OF GROWTH DURING THE GROWING SEASON AT AMES, IOWA, 1923.

	No. plants	Percent infection of					
Date	examined	Leaves	Tassels	Nodal buds	Ears		
July 20-25	3,500	1.5	0.0	0.5	0.0		
Aug. 5-10	17,255	1.7	1.9	0.9	0.1		
Aug. 25-30	17,255	1.8	2.2	3.4	1.3		

By referring to Table II, it may be noted that at the time of the first reading, July 20 to 25, infection was limited largely to the leaves. Of the 3,500 plants that were examined, 1.5 percent were infected in the leaves and 0.5 percent in the nodal buds. By August 5 to 10, infection of the leaves and of the nodal buds showed very little increase. Ear-infection had just begun to manifest itself by this time. The highest percentage of infection, however, was on the tassels. Of the 17,255 plants that were examined at this time, 1.9 percent were attacked in the tassel, 1.7 percent in the leaves, 0.9 percent in the nodal buds and 0.1 percent in the ear. At the time the last readings were made, August 25 to 30, leaf-infection and tassel-infection showed very little increase over the previous reading. Nodal-infection and ear-infection, however, showed a marked increase. Of the 17,255 plants examined, 3.4 percent were infected at the nodes, 2.2 percent in the tassel, 1.8 percent in the leaves and 1.3 percent in the ears. During the growing season, therefore, the disease was at first most prevalent on the leaves, then on the tassels and finally at the nodes. The diseased plants were infected most often in the axillary buds at the nodes and least often in the ears.

Observations in 1927.

Data on the occurrence of corn-smut infection, similar to the data secured in 1923 were gathered in 1927 from 17 plots of Reid's Yellow Dent corn. The results of this study are presented in Tables III and 1V.

The data recorded in Table III show that there was a successive increase in the number of plants infected with smut during the growing season in each of the 17 plots. When the first reading was made, July 20-25, 0.4 to 14.4 percent of the plants in the different plots were infected. By August 20 to 25, when the second reading was made, the percentage of smutted plants ranged from 0.8 to 21.7 percent in the several plots. When the last reading was made, August 25-30, 2.1 to 34.0 percent of the plants in the different plots had become infected with smut. Of the 3,974 plants examined in the 17 plots, 5.1 percent were infected by July 20 to 25. 8.9 percent by August 5 to 10, and 15.7 percent by August 25 to 30.

TABLE III. PREVALENCE OF SMUT-INFECTION IN 17 PLOTS OF REID'S YELLOW DENT CORN (STRAIN IODENT) NEAR AMES, IOWA, 1927.

Plants		Smut-infection	
Examined	July 20-25	August 5-10	August 25-30
No.	Percent	Percent	Percent
135	0.7	3.0	7.4
151	6.6	10.6	17.9
142	6.3	11.9	12.6
244	1.2	5.3	11.9
252	1.5	3.5	10.3
278	0.7	1.4	2.1
246	0.4	0.8	3.6
230	2.6	4.3	7.4
247	2.4	4.8	10.9
284	4.2	8.8	9.1
222	1.8	3.6	27.0
234	6.4	8.5	11.9
236	14.4	17.3	22.4
235	8.1	8.5	11.0
284	3.5	13.0	27.4
264	12.8	20.4	34.0
290	11.7	21.7	30.3
Total			
3,974	5.1	8.9	15.7

Table IV shows that at the time of the first reading, July 20 to 25. the infection was largely limited to the leaves. Of the 3,974 plants examined, 4.9 percent were infected in the leaves and 0.1 percent in the nodal buds. No infection had occurred on the tassels nor on the ears at this time. By August 5 to 10, however, 5.5 percent of the plants were infected in the leaves, 2.7 percent in the nodal buds, and 0.9 percent in the tassels, though there was no infection on the ears. When the last reading was made, August 25 to 30, 5.9 percent of the plants showed nodal-infection, 5.7 percent leaf-infection, 3.6 percent tassel-infection, and 0.2 percent ear-infection. During the growing season, therefore, the smut was at first most prevalent on the leaves, but later most prevalent at the nodes. The axillary buds at the nodes were most often attacked and the ears least often.

TABLE IV. CORN-SMUT INFECTION ON VARIOUS ORGANS OF THE PLANTS AT THREE DIFFERENT STAGES OF GROWTH DURING THE GROWING SEASON, 1927

	No. plants	Percent infection of				
Date	examined	Leaves	Tassels	Nodal buds	Ears	
July 20-25	3,974	4.9	0.0	0.1	0.0	
Aug. 5-10	3,974	5.5	0.9	2.7	0.0	
Aug. 25-30	3,974	5.7	3.6	5.9	0.2	

COMPARISON OF THE PREVALENCE OF CORN SMUT INFECTION ON THE STRAIN IODENT CORN NEAR AMES, IOWA, IN 1923 AND 1927.

The data presented in Tables I and III show that on Reid's Yellow Dent Corn, strain Iodent, smut was more prevalent around Ames, Iowa, in 1927 than in 1923. Of 17,255 plants examined in 1923 there were 7.9 percent infected by smut, whereas, 15.7 percent of 3,974 plants examined in 1927

showed infection. A similar contrast of the prevalence of the disease for the two years as it developed on the leaves, tassels, nodal buds, and ears of the plants, is shown by the data recorded in Tables II and IV. Though the disease manifested itself almost exclusively on the leaves in July of both years, there were 3.06 times as many plants with leaf-infection at the same time in 1927 as there were during the corresponding time in 1923. By the first week in August there were 3.2 times as many plants with leaf-infection and 3.0 times as many with nodal-bud-infection in 1927 as in 1923. However, there were only one-half as many plants infected in the tassel in 1927 as in 1923. This irregularity in the prevalence of the smut for the two years is due, no doubt, to the fact that much of the corn was not in tassel when the second reading on smut-infection was made in 1927, whereas, in 1923 most of the corn was tasseled out before the first of August. By the end of August, when the last reading was made, there were 3.2 times as many plants with leaf-infection, 1.6 times as many with tassel-infection and 1.7 times as many with nodal-bud-infection in 1927 as in 1923. Ear infection was just beginning to manifest itself when the last reading of smut-infection was made in 1927, August 25 to 30, whereas, it was well established at the corresponding time in 1923. It is impossible, therefore, to make a comparison of the total number of plants that were infected in the ear in 1923 and 1927.

WEATHER CONDITIONS IN JUNE, JULY AND AUGUST, 1923 AND 1927, AT AMES, IOWA.

In an attempt to determine whether the difference in the prevalence of corn smut in 1923 and 1927 was in any way dependent upon the weather, the reports of the United States Weather Bureau for Ames, Iowa, were reviewed. A summary of the records for June, July and August, 1923 and 1927, is given in Table V.

TABLE V. SUMMARY OF THE OFFICIAL WEATHER REPORTS FOR AMES, IOWA (JUNE, JULY AND AUGUST, 1923 AND 1927).

Me	an tem	p. Fah	r.	Rainfall							
No. times Amt.			No. times			Amt. ir	inches				
Year	June	July	Aug.	June	July	Aug.	Total	June	July	Aug.	Total
1923	71.0	77.2	70.1	10	3	16	29	5.29	0.69	7.81	13.79
1927	66.9	75.3	68.4	11	8	9	28	1.26	1.25	1.41	3.92

Table V shows that the weather during June, July and August, 1927, was cooler and drier than during the corresponding months of 1923. The mean temperature for June, 1923, was 71.0° F., for July, 77.2° F., and for August, 70.1° F. For June, 1927, it was 66.9° F., for July, 75.3° F., and for August, 68.4° F. During the three months included in the report 13.79 inches of rain fell in 1923 and 3.92 inches in 1927. The rainfall for the three months was distributed as follows: In June, 1923, it rained 10 times with a total precipitation of 5.29 inches, whereas in June, 1927, it rained 11 times with a total precipitation of 1.26 inches. In July, 1923, there were three rainfalls, totalling 0.69 inches, and in July, 1927, there were 8 rainfalls, totalling 1.26 inches. The precipitation for both years was greater in August than for June or July. In August, 1923, it rained 16

times with a total precipitation of 7.81 inches, and in August, 1927, there were 9 rainfalls totalling 1.41 inches. Though there was only one more rainfall in June, July and August, 1923, than there was during the corresponding months in 1927, three and one-half times as much rain fell in 1923 as in 1927.

Though the observations for two years are not sufficient evidence upon which to base a definite conclusion, the above data indicate that, if weather conditions have any effect upon corn-smut infection, it is an effect upon the host, as has been suggested by Potter and Melchers (14), rather than upon the pathogen. Since there was only one more rainfall in June, July and August, 1923, than during the corresponding months of 1927, it does not seem probable that rainfall, as a factor influencing the development of the pathogen, was directly responsible for the difference in the prevalence of corn-smut infection near Ames, Iowa, for these two years. As the germination of the chlamydospores of Ustilago zeae and the subsequent growth of the fungus occur readily in moist atmosphere at 20° to 30° C., the moisture and temperature relations for both years were such as to favor the development of the fungus. However, since there was three and one-half times as much precipitation in June, July and August, 1923, as during these months in 1927, there was a marked difference in the growth of corn for the two years which may have influenced the prevalence of smut. For instance, it is known that corn-smut develops within 10 to 14 days after infection takes place and the observations of the writer showed that not much smut had developed until about the middle of July in 1923 and 1927. If, then, the weather in June is relatively cool and dry, as was the case in 1927, so that the growth of corn is greatly retarded, it is possible that warmer weather in July or August, accompanied by sufficient rain to produce a more rapid growth of corn after it has been thus retarded, may develop plants that are susceptible to infection by Ustilago zeae.

DISTRIBUTION OF THE SMUT ON CORN PLANTS INFECTED WITH $USTILAGO\ ZEAE$

In determining what parts of a corn plant are most commonly attacked by corn-smut, the position of each outbreak of the disease was noted on the 627 diseased plants that were examined in 1927. The instances in which more than one part of the plant had been attacked by the pathogen were recorded as well as the single infections. A summary of this study is presented in Table VI.

By referring to Table VI, it may be noted that most of the smut-infection was limited to one specific point on the plant. In 32.9 percent of the infected plants, smut occurred at several different points on the same plant. In 67.1 percent, however, it occurred at only one point on the plant, distributed as follows: 11.3 percent were infected in the leaf-blade, 0.3 percent in the leaf-sheath, 24.5 percent in the tassel, 29.9 percent at the node, and 1.1 percent in the ear. Of those plants in which the smut was more general in its attack, 1.0 percent were infected in the leaf-blade and leaf-sheath, 11.0 percent in the leaves and tassel, 7.0 percent in the leaves and at one or more nodes, 5.6 percent in the leaves, tassel and at one or more nodes, 2.1 percent in the tassel and at one or more nodes, 4.1 percent at two or more nodes and 0.3 percent in the ear and at one or more nodes. In 1.8 percent of the infected plants, the pathogene had attacked

the entire top of the plant so that it became so misshapen that the specific points of infection could not be determined,

TABLE VI. DISTRIBUTION OF THE SMUT ON 627 CORN PLANTS NATURALLY INFECTED WITH USTILAGO ZEAE in 1927 NEAR AMES, IOWA.

Location of infection on plants	Plants	infected
	No.	Percent
Leaf blade only	71	11.3
Leaf sheath only	2	0.3
Leaf blade and sheath	6	1.0
Leaf and tassel	69	11.0
Leaf and one node	8	1.3
Leaf and several nodes	36	5.7
Leaf, tassel and one node	6	1.0
Leaf, tassel and several nodes	29	4.6
Tassel only	154	24.5
Tassel and nodes	13	2.1
One node only .	187	29.9
Several nodes	26	4.1
Ear and nodes	2	0.3
Ear only	7	1.1
General attack	11	1.8

The data presented in Table VI show that the most smut occurred at the nodes. Of 627 plants infected with the disease, 307 showed nodal-infection and of these 187 were infected at one node only. As has been pointed out by other workers, it was noted by the writer that nodal-infection is almost exclusively due to infection of the axillary buds. It was noted, also, that the buds at the lower nodes, the second and fifth from the base of the plant, are most commonly infected. It appears, therefore, that the most vulnerable point for infection of Zeae mays by Ustilago zeae in the field is the axillary buds at the lower nodes of the plants.

In studying the distribution of smut on the corn plant, it was noted that leaf-infection manifests itself in various ways. The infected areas may be only discolored, as is shown in Figs. 1, 2 and 3 of Plate IA and Fig. 3 of Plate IB. These discolored areas are usually in the form of small irregular, yellow blotches. Sometimes, however, they occur in streaks or large blotches. Occasionally, dark red spots are found in the infected area. A characteristic example of this type of infection is shown in Figs. 1 and 2 of Plate IB. Small boils, on the other hand, are also formed on the leaves as may be seen in Figs. 1 and 2 of Plate IB and Fig. 3 of Plate IIA. A very common symptom of the disease on the leaves is the entire necrosis of the infected tissues and the tearing or dropping out of the diseased portion. Examples of this symptom are shown in Plate IIA and B.

It is evident, therefore, that leaf-infection is very easily overlooked in the field, as it is not always possible to attribute the chlorotic and necrotic symptoms to the true cause. They may be mistakenly attributed to causes other than smut infection or may be regarded as smut symptoms when they are not. On the other hand, the chlorotic symptoms often disappear entirely as the plants grow older and are thus not observed.

ARTIFICIAL INFECTION OF CORN WITH USTILAGO ZEAE

In artificially testing the susceptibility of corn to infection by *Ustilago* zeae, a hypodermic needle was not used, first, because injecting a sporidial

suspension into the meristematic tissue of the plant excludes penetration of the pathogen into its host, and, second, because this method is not comparable to what takes place under natural conditions in the field. Experiments were conducted, therefore, in which plants of successive sizes were treated in various ways as hereinafter described. Some of the experiments were conducted in the laboratory, others in the greenhouse and in the field.

Materials and methods.

Chlamydospores, applied as a dust, and sporidia in suspension in distilled water or dilute carrot decoction, were used in the experiments. About 100 smut boils were gathered during the fall of 1926 near Iowa State College, Ames, Iowa. A relatively clean supply of spores was secured by crushing a large number of these boils into a powder and sifting the crushed material through a fine meshed sieve. Their viability was tested by dusting some of them on the surface of agar agar to which a small amount of benzaldehyde had been added. In these tests 75 to 80 percent of them proved to be viable.

The sporidial suspension was sprayed on the plant or plant part to be inoculated with an atomizer or was dropped on with a pipette or a syringe. In making some of the sporidial suspensions, large petri dishes were used and the chlamydospores were dusted on the surface of a thin layer of agar agar to which a small amount of benzaldehyde had been added. The cultures were kept at 30° C. in an electrically controlled oven for 24 to 36 hours. By this time the sporidia had formed in abundance and by washing the surface of the agar agar with distilled water a sporidial suspension of required concentration was obtained. Concentrations which, when examined with the high-power objective of a microscope, showed from 50 to 100 sporidia to a field were used in the experiments.

Suspensions of pure cultures of sporidia were used in some of the experiments. To obtain a pure culture of sporidia, chlamydospores were washed in an aqueous solution of mercuric chloride (one part HgCl, in 10,000 parts of H.O by weight) for two minutes, after which they were rinsed in sterile, distilled water. These spores were germinated on sterile agar agar to which a small amount of benzaldehyde was added. sporidia were then transferred to carrot-agar slants by means of a sterile needle. From these stock cultures, transfers were made into sterile carrotdecoction prepared by boiling 200 g. of sliced carrots in 1000 c.c. of distilled water for one-half hour, straining the juice through a cloth and sterilizing it in an autoclave for one hour at 10 to 15 pounds pressure. The cultures thus prepared in carrot-decoction were allowed to grow four to six days and were then diluted with distilled water to the concentration of sporidia that was desired for the experiments. The viability of the sporidia was tested by injecting the suspension by means of a hypodermic needle into the growing tip of sweet corn plants (var. Golden Bantam) about six inches tall. Of the 25 plants thus inoculated, 23 were infected and developed smut boils on the leaves and stalk within 10 days after inoculation. The sporidia were, therefore, viable.

As temperature and humidity are two environmental factors to which corn is subjected in the open, these two factors were recorded for each experiment. Because the morphology of the corn plant in its development from a seedling to a mature plant varies greatly, special note was made of

this factor in each experiment. Three kinds of corn were used as host plants in the different experiments, namely, popcorn (var. Japanese Hulless), sweet corn (var. Golden Bantam) and dent corn (var. Reid's Yellow Dent, strain Iodent No. 25).

Infection of seedlings less than one foot tall.

A series of experiments in which corn seedlings were treated with spores of *Ustilago zeae* was conducted in the laboratory. Sweet corn (var. Golden Bantam) was planted in small flower pots, one plant to a pot, and allowed to grow to the desired size. Three different sizes were used; plants from one-half to two inches tall in which the coleoptile was not yet pierced, plants two to four inches tall in which the coleoptile was pierced and one or two leaves were unfolded, and plants four to six inches tall with three or four leaves unfolded. Some plants were treated by dusting them with chlamydospores, others by spraying them with a suspension of sporidia in distilled water.

The plants dusted with chlamydospores were placed in moist chambers and kept at 20°, 25° and 30° C., respectively, in electrically controlled ovens for 24 to 96 hours. Those sprayed with a sporidial suspension also were kept in moist chambers at 20°, 25° and 30° C., for three to 96 hours. Ten plants were treated in each trial. As checks, treated plants and untreated plants were placed on a table in the laboratory where the temperature ranged from 20° to 25° C. All plants were subsequently kept in the open air of the laboratory three to four weeks and examined daily for the development of smut.

Infection of seedlings under the environmental conditions to which the plants of this series of experiments had been subjected was not very successful. The treated plants often showed chlorosis of the leaves. It was difficult, however, to determine whether the chlorosis was due to an attack by smut because the checks occasionally showed similar chlorosis. In no

case did the plants develop smut boils.

Another series of experiments in which corn seedlings were treated with spores of *Ustilago zeae* was conducted in the greenhouse. Popcorn (var. Japanese Hulless), sweet corn (var. Golden Bantam), and dent corn (var. Reid's Yellow Dent, strain Iodent No. 25) were grown in flower pots, three plants to a pot. The seedlings were treated at different stages of growth, ranging from four inches tall with the first leaf beginning to unfold to ten inches tall with two or three leaves unfolded.

In this series of tests, 48 plants were dusted with chlamydospores, 89 were sprayed with a sporidial suspension and 206 were treated by dropping the sporidial suspension into the terminal leaf-spirals with a pipette.

Care was taken in each case not to injure the plants in any way.

After the plants were treated they were subjected to different humidity and temperature relations. Some were kept on the greenhouse bench, some in humidity cages and some in a moist chamber. The air of the greenhouse usually was relatively dry and hot. The temperature, however, fluctuated between 20° and 35° C. The air of the humidity cages was relatively humid and cool. The cages were made of cloth over a greenhouse bench and were four feet high and three feet square in cross section. The air was kept moist and cool by a constant spray of water on the sandy bottom and over the cloth walls. The plants were kept in these cages from one to

three days after being treated and were then placed on the greenhouse bench and examined daily for the development of smut.

The moist chamber used in this series of experiments was made of window-sashes. It was three feet wide, five feet long and four feet high, with glass sides and top. The bottom was made of wood covered with a layer of coarse gravel upon which was placed a thick layer of Sphagnum. The air in the chamber was kept at 30° to 35° C, and at a relative humidity of 100 percent. The plants were kept in the moist chamber one to three days after being treated and were subsequently placed on the greenhouse bench where they could be examined daily for the development of smut.

In each of the experiments, untreated plants were used as checks, and the results of the entire series of tests are shown in Table VII.

The data in Table VII show that 7 percent of the 343 seedlings that were exposed to the spores became infected, whereas the checks remained uninfected. The plants manifested the disease on the young leaves as they unfolded from the terminal leaf-spirals within 10 days after they became

TABLE VII. PERCENTAGE OF INFECTION ON CORN SEEDLINGS, FOUR INCHES TO TEN INCHES TALL, TREATED WIITH CHLAMYDOSPORES OR SPORIDIA AND SUBJECTED TO VARIOUS HUMIDITY AND TEMPERATURE RELATIONS IN THE GREEN HOUSE.

Kind	No.		Humidity	and		P	ercentage
of corn	pl.	Spores	temperat				pl. inf.
Popcorn	18	Chlamydospores	Humidity		20°		
Sweetcorn	16	"	29	27	77	"	12.5ª
Dentcorn	14	22	23	22	22	22	0
Ck.	10	22	27	22	22	22	ŏ
Popcorn	16	Sporidia ¹	29	22	99	22	0
Sweetcorn	15	22	22	22	22	92	ő
Dentcorn	13	27	22	92	99	22	15.0a+b
Ck.	10	22	22	22	22	22	0
Popcorn	15	77	Greenhouse	hench	25°	-30°C	ŏ
Sweetcorn	15	22	"	"	"	"	ŏ
Dentcorn	15	27	"	22	22	22	ő
Ck.	10	39	22	22	92	27	ŏ
Popcorn	15	Sporidia ²	Moist ch	mber	30°	-35°C.	0
Sweetcorn	15	27	"	25	22	"	66.6ª
Dentcorn	15	22	27	29	27	97	13.3ª
Ck.	10	22	22	22	27	22	0
Popcorn	28	99	Humidity	RATTES	20°	-25°C	
Sweetcorn	23	"	"	"	"	"	ŏ
Dentcorn	20	29	33	22	22	22	5.0ª
Ck.	30	29	"	22	22	99	0
Popcorn	15	23	Greenhouse	hench	25°	-35°C.	ŏ
Sweetcorn	15	23	77	27	22	"	ŏ
Dentcorn	15	29	,,,	22	33	22	ő
Ck.	10	99	>>	22	22	22	ŏ
Popcorn	15	,,	,,,	22	20°	-30°C.	ő
Sweetcorn	15	22	32	22	22	"	26.6*
Dentcorn	15	22	"	32	29	22	0
Ck.	10	37	97	92	22	22	ő
Totals	343		1				7.0

¹—Sporidial suspension used as a spray.

²—sporidial suspension dropped into the terminal leaf-spirals.

^{*-}indicates chlorosis and necrosis of infected tissues.

b-indicates development of smut boils.

infected. Some of the diseased leaves showed only chlorotic and necrotic areas. Others, however, developed small smut-boils. The perentage of infection was highest with the sweet corn and least with the popcorn. Of 114 sweet corn plants that were exposed to the spores, 13.1 percent became diseased, whereas 4.6 percent of 107 dent corn plants became infected and 2.5 percent of 122 popcorn plants.

The results obtained in these experiments did not present any conclusive evidence in regard to the relation of infection to temperature and humidity. Likewise no conclusive evidence was obtained in regard to the best method of applying the spores because 10.4 percent of the 48 plants that were dusted with chlamydospores became infected and 8.2 percent of the 206 plants that were treated by dropping a sporidial suspension into the terminal leaf-spirals became infected.

Infection of plants one foot to one and one-half feet tall.

In the above series of experiments it was noted that the larger seedlings, plants about 10 inches tall, were more readily infected than the smaller ones by dropping the sporidial suspension into the terminal leaf-spirals. A series of experiments was planned, therefore, in which plants one foot to one and one-half feet tall were treated with chlamydospores or sporidia. In these experiments, popcorn (var. Japanese Hulless), sweetcorn (var. Golden Bantam), dent corn (var. Reid's Yellow Dent, strain Iodent No. 25), and inbred strains of several different varieties of dent corn were used as hosts. These strains had been selfed in the field for three or four years. On strains 1 S to 25 S a relatively high percentage of smut had developed each year that they were grown. On strains 1 R to 15 R no smut had developed for four years.

Corn plants for the experiments were grown singly in six-inch flower pots in the greenhouse until they were one foot to one and one-half feet tall. Some of the plants were then dusted with chlamydospores and others were treated by dropping a suspension of sporidia in carrot decoction into the terminal leaf-spirals with a syringe. Care was taken in each case to avoid injuring the plants. The end of the syringe was never inserted into the leaf-spirals nor allowed to come in contact with the leaves.

After the plants were treated they were subjected to various humidity and temperature relations by using the greenhouse bench, the humidity cages, and the moist chamber as in the preceding experiment. After one to three days all were placed on the greenhouse bench. The relative humidity of the air in the greenhouse was not very constant. It was kept comparatively high by frequently spraying the floors and benches with water and by keeping the ventilators closed. As checks in these experiments, some plants were left untreated and some were treated with a dilute carrot decoction containing no sporidia. All plants were examined daily for symptoms of infection and only that infection which occurred within 10 to 15 days was considered to be artificial. The results of the tests are presented in Tables VIII and IX.

³The writer is indebted to Dr. M. T. Jenkins of the Office of Cereal Investigations, U. S. Dept. Agr., Washington, D. C., from whom the seed of the inbred strains of corn were obtained.

TABLE VIII. PERCENTAGE OF INFECTION ON CORN PLANTS, ONE FOOT TO ONE AND ONE-HALF FEET TALL, TREATED WITH CHLAMYDOSPORES OR SPORIDIA AND SUBJECTED TO VARIOUS HUMIDITY AND TEMPERATURE RELATIONS IN THE GREENHOUSE.

Kind of	No.			Percentage
corn	[pl.]	Spores	Humidity and temperature	plant inf.
Popcorn	20	Chlamydospores	Humidity cages 20°-30°C.	5.0b
Sweetcorn .	18	","	, , , , , , ,	11.1 ^b
Dentcorn	10	33	27 22 22 22	20.0 ^b
Sweetcorn	48	23	Moist chamber 25°-35°C.	8.3a+b
Sweetcorn	126	Sporidia	Greenhouse bench 20°-30°C.	32.5ª
Dentcorn	69	~ n	27 27 29 29	28.9
Popcorn	15	22	" 25°-35°C,	0.0
Sweetcorn	15	23	22 22 22 22	60.0ª
Dentcorn	15	29	" " " "	0.0
Popcorn	15	33	Humidity cages 20°-25°C.	20.0°
Sweetcorn	15	23	" " " "	66.6ª
Dentcorn	15	27	" " " "	20.0ª
Sweetcorn	87	23	Moist chamber 30°-35°C.	57.4ª
Totals	468			30.9
Ck.	218			1.3

^{*-}indicates chlorosis and necrosis of infected tissues.

By referring to Table VIII it may be noted that 30.9 percent of the 468 plants that were treated became infected, whereas only 1.3 percent of the 218 checks showed symptoms of smut. The sweetcorn was again more susceptible than the dent corn, which, in turn, was more susceptible than the popcorn. As the temperature and humidity relations to which the plants were subjected were not definitely controlled, but were simply observed and recorded, the data do not present conclusive evidence of their significance to infection. However, temperatures ranging from 20° to 35° C, were favorable to an effective inoculation and high relative humidity seemed to favor infection.

The results of the experiments indicate that plants one foot to one and one-half feet tall are more susceptible to infection than seedlings less than one foot tall. They also indicate that dropping a suspension of sporidia into the terminal leaf-spirals of the plants is a more effective method of obtaining artificial infection than dusting the plants with chlamydospores. Of the 96 plants that were dusted with chlamydospores, 9.3 percent became infected, whereas 36.5 percent of the 372 plants that were treated by dropping a suspension of sporidia into the terminal leaf-spirals showed symptoms of smut.

Most of the infection obtained by dropping the sporidial suspension into the leaf-spirals of the plants occurred on the leaves as chlorosis and necrosis of the infected tissues. In many cases the discolored areas entirely disappeared as the plants grew larger, though, occasionally, small boils developed on the infected leaves, as shown in Plate IIIA. Some of the larger plants, however, developed smut boils on the tassels and at the upper nodes due to infection of the growing tips. Examples of such an infection are shown in Plate IIIB, C, IV and V.

b-indicates development of smut boils.

TABLE IX. PERCENTAGE OF INFECTION ON SEEDLINGS OF INBRED STRAINS OF DENT CORN TREATED WITH SPORIDIA AND SUBJECTED TO VARIOUS HUMIDITY AND TEMPERATURE RELATIONS IN THE GREENHOUSE.

Strain	Number plants exposed	Location	Temperature	Number and plants in	d percent
	19	Greenhouse bench	25°-30°C.	14ª	73.6
18		Greenhouse bench	27 27	9ª+1b	47.6
2 S	21	27 27	22 22	5ª	66.6
3 S	15 13	27 27	27 29	5ª	38.4
4 S	18	27 27	27 29	6ª	33.3
5 8		22 23	22 22	5ª	26.3
6 S	19 20	27 27	22 23	4ª	20.0
7 8		27	27 29	1ª	11.1
8 S	9	22 22	22 22	4ª	25.0
9 8	16	27 22	22 22	11ª+1b	66.6
10 S	18	23 22	22 22	6ª	28.5
11 S	21	. 27 27	22 22	6ª	27.2
12 S	22	22 22	22 23	7a	33.3
13 S	21	27 27	22 22	7*	33.3
14 S	21	22 22	22 22	8a	38.1
15 S	21	22 22	22 23	0	0.0
16 S	6	2) 2)	22 23	0	0.0
17 S	6	"	22 22	0	0.0
18 S	6	" "	22 23	1*	25.0
19 S	4	>> >> >>	22 22	0	0.0
20 S	2	" "	" "	0	0.0
21 S	6	" "	22 22	0	0.0
22 S	6	" "	,, ,,	0	0.0
23 S	2	" "	22 22	1"	33.3
24 S	3	" "	,, ,,	1ª	25.0
25 S	4	" "			32.6
Totals	319		1	103	2.0
Ck.	50		25°-30°C.	1 1ª	50.0
1 R	2	Greenhouse bench	25°-30°C.		0.0
2 R	5	77 79 79 79	72 22	0 2ª	28.5
3 R	7		" "		0.0
4 R	5		29 29	0	0.0
5 R	3		" "	0	0.0
6 R	6		" "	0	0.0
7 R	7		27 77	0	
8 R	4	29 29		2ª	50.0
9 R	1 1	39 39	39 99	0	0.0
10 R	1.	2) 2)	27 27	0	0.0
11 R	1	?? ? ?	""	0	0.0
12 R	1 1	?? ??	""	1ª	100.0
13 R	1 1	22 22	" "	1ª	100.0
14 R	1	?? ??	""	0	0.0
15 R	1	22 23	""	0	0.0
Totals	46			7	15.2
Ck.	23			0	0.0

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Strain	Number exposed plants	Location	Temperature		and percent infected
18	3	Humidity cages	20°-25°C.	13	33.3
2 S	2	n \tilde{n}	""	0	0.0
3 S	3	22 22	" "	2*	66.6
4 S	2	27 29	22 22	0	0.0
5 S	2	77 79	22 22	1ª	50.0
6 S	3	27 29	22 29	12	33.3
7 S	2	22 29	27 29	0	0.0
8 S	1	27 29	22 23	0	0.0
9 S	3	22 22	22 22	1ª	33.3
10 S	2	22 23	22 22	[1a	50.0
11 S	2	77 77	27 27	0	0.0
12 S	3	22 22	22 22 ,	1ª	33.3
13 S	2	" "	22 22	0	0.0
14 S	2	22 22	22 23	1ª	50.0
15 S	3	22 22	22 22	1a	33.3
Totals	35			10	28.5
Ck.	29			0	0.0
2 R	1	Humidity cages	20°-25°C.	10	100.0
3 R	1	" "	22 23	0.	0.0
8 R	1	22 22	22 22	1ª	100.0
11 R	ī	" "	22 23	1 ō	0.0
14 R	1	" "	" "	Ŏ	0.0
15 R	1			1ª	100.0
Totals	6			3ª	50.0
Ck.	6			0	0.0

[&]quot;-indicates chlorosis and necrosis of infected tissues.

The data presented in Table IX show that by dropping a suspension of sporidia into the terminal leaf-spirals of the plants of inbred strains of corn, infections were obtained in the strains that showed resistance in the field as well as in the strains that were susceptible. Of the 406 plants that were thus exposed, 123 became infected, whereas only one of the 108 plants used as checks showed symptoms of smut. The strains that had developed smut in the field for several years proved to be quite susceptible to infection in the greenhouse. Of the 354 plants that were exposed by dropping the sporidial suspension into the terminal leaf-spirals, 32 percent became infected. However, due to a lack of sufficient seed, enough trials were not made with each strain to obtain conclusive results. The strains that had not developed smut in the field for several years did not show the same degree of resistance to infection in the greenhouse. Twenty percent of the 52 plants that were exposed with the sporidial suspension became infected. With these strains, also, it was impossible to obtain conclusive results due to a lack of seed.

Of the plants that were kept on the greenhouse bench at 25° to 30° C., 30.1 percent became infected, and 31.6 percent of those placed in the humidity cages at 20° to 25° C. Therefore, it seems that the difference in the humidity and temperature of the two environments did not influence infection.

b-indicates development of smut boils.

Infection of plants two to four feet tall.

Much of the natural infection of corn by *Ustilago zeae* seems to take place when the plants are approaching maturity. Such attacks produce smut at the lower nodes and on the ears. A series of experiments was conducted, therefore, in which plants ranging from two to four feet tall were treated in various ways. Popcorn (var. Japanese Hulless), sweetcorn (var. Golden Bantam), and dent corn (var. Reid's Yellow Dent, strain Jodent No. 25) were grown in the greenhouse for these experiments.

Six-inch flower pots were used for plants two to three feet tall and two-gallon earthen jars for the more mature plants. Some of the plants were dusted with chlamydospores, some were sprayed with a suspension of sporidia in distilled water and some were exposed by dropping a suspension of sporidia in carrot decoction into the terminal leaf-spirals of the plants just before the tassels appeared. Some of the plants were mutilated

TABLE X. PERCENTAGE OF INFECTION ON THE PLANTS TWO TO FOUR FEET TALL TREATED WITH CHLAMYDOSPORES OR SPORIDIA AND SUBJECTED TO VARIOUS HUMIDITY AND TEMPERATURE RELATIONS IN THE GREENHOUSE.

Kind of corn	Number plants treated	Spores	Location	Tempera- tures	Percent plants infected	
Sweetcorn	30	Chlamydospores	Greenhouse bench	20°-30°C.	0.0	
Dentcorn	30	"	27 27	27 27	0.0	
Sweetcorn	30	>>	Moist chamber	25°-35°C.	0.0	
Sweetcorn	19°	29	59 99	22 22	0.0	
Porcorn	55 ^d	Sporidia	Greenhouse bench	20°-30°C.	0.0	
Sweetcorn	82ª	25	27 27	22 22	10.9 ^b	
Sweetcorn	25°+d	22	27 29	22 22	0.0	
Dentcorn	55 ^d	29	22 22	22 22	0.0	
Porcorn	55 ^d	59	Humidity cages	20°-25°C.	0.0	
Sweetcorn	55 ^d	22	,, ,,	22 22	0.0	
Dentcorn	55 ^a	23	22 22	22 22	0.0	
Sweetcorn	52d	>>	Moist chamber	18°-20°C.	0.0	
Sweetcorn	33°	22	22 22	22 22	3.0a+b	
Sweetcorn	65 ^d	9.9	- 22 22	20°-25°C.	0.0	
Sweetcorn	20°+4	22 .	27 27	22 22	0.0	
Sweetcorn	42°	22	" "	22 27	0.0	
Sweetcorn	16 ^d	22	22 22	25°-35°C.	0.0	
Sweetcorn	20°	59	29 29	22 22	0.0	
Sweetcorn	18 ^d	22	22 . 22	30°-35°C.	11.1 ^b	
Totals	757				1.6	
Ck.	324				2.5	
C .	018	G	Carrel and banch	20°-30°C.	1.2 ^b	
Sweetcorn	81 ^e	Sporidia .	Greenhouse bench	20 -30 C.		
Ck.	81	"	"	22 22	0.0 36.8 ^b	
Sweetcorn	106 ^g	"		, ,,		
Ck.	200				0.0	

^{*-}indicates chlorosis and necrosis of infected tissues.

b-indicates development of smut boils.

^{&#}x27;-plants mutilated before treating with spores.

suspension of sporidia used as a spray.

^{*-}suspension of sporidia dropped into leaf-spirals.

suspension of sporidia dropped behind leaf-sheaths.

⁻suspension of sporidia dropped into ends of ears.

by piercing and crushing the leaves and stem before they were exposed with the spores. As in previous experiments, the plants were subjected to various temperature and humidity relations after they were exposed and untreated plants were used as checks.

In another series of experiments, an attempt was made to infect the axillary buds and young ears of the plants. The sporidial suspension was dropped behind the leaf-sheaths and into the distal end of the young ear. The results of these two series of experiments are summarized in Table X.

As may be noted by referring to Table X, plants two to four feet tall were not readily infected artificially in the greenhouse. Only 1.6 percent of the 757 plants that were exposed became infected, whereas 2.5 percent of the 324 checks showed symptoms of smut. None of the plants that were dusted with chlamydospores were infected. Likewise, none of the plants that had been mutilated developed any smut. Five plants that had been exposed with a suspension of sporidia developed smut boils. Whether these were artificially infected is not known, since a higher percentage of the checks became diseased. Only one of the 81 plants that were exposed by dropping the sporidial suspension behind the leaf-sheaths became infected. This plant developed a smut boil on one of the rudimentary ears and was probably artificially infected since none of the checks developed any smut.

Artificial infection of the young ears was quite successful. Of the 106 plants that were exposed by dropping the sporidial suspension into the ends of the ears, 36.8 percent developed smutted ears. Since none of the 200 plants used as checks produced smutted ears, the smut on the exposed plants was undoubtedly produced from artificial infection.

Infection of plants in the field.

During the summer of 1927, corn was exposed in the field by dropping a suspension of sporidia in carrot decoction into the terminal leaf-spirals of the plants. A glass pipette was used in exposing the small plants and a veterinary's syringe for the large plants. Care was taken in each case not to injure the plants with the instrument. In order that different sizes of plants might be exposed under similar climatic conditions, several successive plantings of corn were made during the summer. On May 13, popcorn (var. Japanese Hulless), sweet corn (var. Golden Bantam), and dent corn (var. Reid's Yellow Dent, strain Iodent No. 25) were sown in rows three feet apart. The kernels were placed two to three inches apart. Treatment of this corn was begun June 16, when the plants were six inches to one foot tall, and was continued until July 13, when the plants were three to four feet tall. Treatments were made twice daily, in the morning and evening, for the first ten days. Fifty to 100 plants were exposed each time. As checks, the plants of adjacent rows were not exposed.

On May 20, two rows of popcorn (var. Japanese Hulless) were planted, in which three to five kernels were planted in hills two feet apart. Treatment of the plants of one of these rows was begun July 4, when the corn was 10 to 12 inches tall, and was continued every second day until July 12. Twenty-four plants were exposed daily during this time. The plants of the other row of this planting were used as checks.

Another planting of popcorn (var. Japanese Hulless), sweetcorn (var. Golden Bantam), dent corn (var. Reids Yellow Dent, strain Iodent No. 25) was made June 10. This corn was planted in hills three feet apart with

three to four kernels to a hill. Treatment was begun July 4, when the corn was six inches to one foot tall and was continued every second day until July 28, when the corn was three to five feet tall. Some plants were exposed daily for the first ten days. Plants of alternate rows were left untreated as checks,

Several rows of dent corn (var. Reid's Yellow Dent, strain Iodent No. 25) were planted June 15, in hills three feet apart. Treatment of this corn was begun July 7, when the plants were eight inches to one foot tall and was continued daily until July 12, when the plants were about two feet tall. Just before the tassels began to show, plants four to five feet tall were exposed August 1 to 3. Adjacent rows of corn were used as checks.

A third planting of popcorn (var. Japanese Hulless), sweetcorn (var. Golden Bantam) and dent corn (var. Reid's Yellow Dent, strain Iodent No. 25) was made June 18. The corn was planted in hills three feet apart, with three to five kernels to a hill. Treatments were made August 1, 3, 5, and 7. On August 1, the popcorn was two to three feet tall, the sweetcorn two and one-half feet tall and the dent corn three to four feet tall. The tassels could not be seen on any of the corn at this date. By August 7, the tassels of most of the corn were beginning to appear. As in previous experiments, plants not exposed in alternate rows were used as checks.

The corn in each of the above series of experiments was examined daily for symptoms of smut. A record was kept of the number of exposed plants that became infected and the number of infected checks (Table XI).

TABLE XI. PERCENTAGE OF INFECTION ON CORN TREATED IN THE FIELD BY DROPPING A SUSPENSION OF SPORIDIA INTO THE TERMINAL LEAF-SPIRALS.

	1		1						Checks		
Kind of	Dat	e	Date			No. No. & percent		No. No. & percent			
corn	plant	ed	treated			plants	plts.	infected	plants plants inf.		nts inf.
Popcorn	May	13	June	16-Jul.	13	1179	5	0.4	1163	0	0.0
Sweetcorn	22	22	22	22 22	22	1158	31	2.6	1275	27	2.1
Dentcorn	22	22	22	22 27	22	782	5	0.6	856	4	0.4
Popcorn	May	20	July	4-Jul.	12	138	22	15.9	157	42	26.6
Popcorn	June	10	22	22 22	16	332	0	0.0	383	0	0.0
Sweetcorn	99	99	22	22 22	28	512	9	1.7	531	3	0.5
Dentcorn	22	22	32	22 32	27	518	74	14.2	509	53	10.4
Dentcorn	. 95	15	22	7-Aug.	3	810	47	5.8	770	51	6.6
Popcorn	33	18	Aug.	1-Aug.	3	100	4	1.0	100	0	0.0
Sweetcorn	22	27	22	1- "	7	363	5	1.3	224	1	0.4
Dentcorn	22	22	22	22 22	22	338	19	5.6	309	13	4.2
Totals						6230	218	3.5	6277	194	3.1

Artificial infection of corn in the field by dropping a sporidial suspension into the terminal leaf-spirals was not very successful, as may be noted by referring to Table XI. Of the 6,230 plants that were thus exposed, 3.5 percent became infected. However, 3.1 percent of the 6,277 plants used as checks were diseased with corn smut. In no case, therefore, was the percentage of infected plants much higher in the exposed corn than in the checks. In two series of the experiments, on the other hand, the checks showed a higher percentage of infection than the exposed plants.

DISCUSSION

A review of recent studies on the infection of Zeae mays by Ustilago zeae presents two distinct interpretations of the data that have been gathered. In the first place, the results of the work of Christensen and Stakman (3) and Stakman and Christensen (15) indicate that the factors governing infection are largely dependent on the biological condition of the pathogen.

On the other hand, the findings of Hayes et al (7), Garber and Quisenberry (5), Immer (9), and Griffiths (6) suggest that resistance and susceptibility of corn to smut are dependent upon the morphology of corn plants. It is worthy of note, also, to recall that Brefeld (2) selected plants about one foot tall with characteristically large, open terminal leaf-spirals in the series of experiments in which he obtained 100 percent infection. Apparently, the structure of the terminal leaf-spirals of these plants was an important factor in inducing such a high percentage of infection in his experiments.

From the results obtained in the foregoing experiments in which plants were infected by dropping sporidial suspensions into the terminal leaf-spirals, it seems evident that corn plants about one foot tall are more susceptible to infection by corn smut than either smaller or larger plants. The explanation, in all probability, lies in the difference in the morphology of the plants in these successive stages of growth. This difference in morphology may be noted by examining the transverse and longitudinal sections of plants in various stages of development. Diagrams of sections of a plant five inches tall and of one fifteen inches tall are shown in Plates VI to IX.

In small corn seedlings the growing tip is very short and, together with numerous delicate leaf-primordia, is deeply set in the enveloping leaves that have unfolded. The unfolding leaves are rather firmly packed together in these plants. As the plants grow larger, however, the growing tip becomes longer and the enveloping, unfolding leaves become less compact. At this stage of growth, the growing tip and the delicate leaf-primordia surrounding it are accessible, therefore, to a suspension of sporidia dropped into the characteristic terminal leaf-spirals formed by the unfolding leaves. It is the delicate leaf-primordia and the growing tip or tassel that become infected when plants are exposed by this method.

On the other hand, plants two to four feet tall may, likewise, be morphologically protected against infection when a suspension of sporidia is dropped into their terminal leaf-spirals. Though the tassels of some of the plants at this stage of growth are still enveloped by the upper leaves they are almost completely developed by this time. It is possible, therefore, that their exposed surface is covered throughout with firm epidermal tissue, which the germinating sporidia may not be able to penetrate.

The survey of natural infection by *Ustilago zcae* in the field showed that the axillary buds are most commonly infected. Though an attempt was made to infect these buds artificially, sufficient trials were not made with different stages of development of the buds to obtain conclusive data regarding the relation of the morphology of the corn plants to infection of these buds. The biological differences between various strains of corn and the biological differences between the various strains of smut probably are influencing factors to natural infection by *Ustilago zeae*. How-

ever a consideration of the relation of the morphology of the corn plant to infection must not be overlooked. The gross morphology of different strains of corn may vary sufficiently at corresponding stages of growth so that susceptible parts of the plant may be more openly exposed to an attack by smut in some strains than they are in others. Resistance to smut, there-

fore, may be largely morphological rather than biological.

It is especially necessary to consider the morphological factor in selecting a method of artificially infecting various strains of corn to determine their relative resistance to smut. Injecting a sporidial suspension into the meristematic tissues of the plants, the method that is commonly used at present, does not take the morphological factor into consideration because it excludes the factor of penetration by the pathogen into its host. It appears, therefore, that dropping a suspension of sporidia into the terminal leaf-spirals or on other susceptible parts of the plants that are accessible from the exterior is a better method because it is more comparable to what must take place in nature.

SUMMARY

A survey of corn smut near Ames, Iowa, in 1923 and 1927 showed that the disease was more prevalent in 1927. The mean temperature during the growing season of 1927 was somewhat lower than that of 1923 and the rainfall was much less. During June, July and August, 1923, there were 29 rainfalls and in the corresponding time, 1927, there were 28. However, during three months in 1923, 13.79 inches of rain fell and only 3.92 inches in 1927. A season in which relatively cool, dry weather in June was followed by a period of rain and higher temperature seemed to favor the disease.

Corn smut did not manifest itself much before July 20. Beginning about this time, there was a distinct, successive manifestation of the disease on different parts of the plants. It was first found to be most prevalent on the leaves, then on the tassels, next at the nodes, and finally on the ears. Infection of the axillary buds at the nodes, however, was more common than attacks on any other part of the plants.

Most of the smut was limited to individual, specific parts of the plants. In 67.1 percent of 627 diseased plants, only one part of the plant was attacked. In 32.9 percent of the plants, two or more parts of the stalk were infected and in 1.8 percent the entire top of the plant was attacked so

that the specific points of infection could not be determined.

A study of leaf-infection showed that it manifests itself in various ways. The infected areas may be small, irregular, yellow blotches and occasionally dark red spots are found in the infected area. The diseased portion of the leaf is often crinkled so that its surface is wavy instead of flat. A common symptom of the disease is the entire necrosis of the infected tissues and the tearing or dropping out of the diseased portion. The chlorotic areas, on the other hand, may disappear entirely as the leaf grows older. Smut boils may also form on the leaves and they are usually relatively small.

Artificial infection of corn with *Ustilago zeae* indicated that plants from one foot to one and one-half feet tall were more susceptible to infection than either smaller plants, one-half inch to ten inches tall, or larger

plants, two to four feet tall.

Apparently, plants about one foot tall expose the growing tip and the delicate young leaves surrounding it, to such a degree that they are accessible to the spores. In smaller plants the growing tips are too deeply seated and protected to be readily reached by a dust or a spray of the spores. Plants more than two feet tall, on the other hand, have growing tips that are almost fully developed. Their exposed surfaces are probably covered throughout with firm epidermal tissue which may be impenetrable to the germ-tubes of the sporidia.

Experiments conducted in the greenhouse showed that sweetcorn (var. Golden Bantam) was more susceptible to *Ustilago zeae* than dent corn (var. Reid's Yellow Dent, strain Iodent No. 25), which in turn was more suscep-

tible than popcorn (var. Japanese Hulless).

Inbred strains of dent corn that had not developed smut in the field for several years, did not show the same degree of resistance to infection in the greenhouse when a sporidial suspension was dropped into the terminal leaf-spiral of the plants.

Dropping a suspension of sporidia into the terminal leaf-spirals of the plants was more successful in producing infection than dusting them with

chlamydospores or spraying them with a suspension of sporidia.

Mutilating the plants before dusting them with chlamydospores or spraying them with a suspension of sporidia did not induce infection.

Temperatures ranging from 20° to 35° C. were favorable to an effective, artificial infection and a high relative humidity seemed to favor infection.

Dropping the sporidial suspenson behind the leaf-sheaths in an attempt to infect the axillary buds was not successful. However, young ears were readily infected by dropping the suspension into their distal ends.

Artificial infection of corn in the field during the summer of 1927 by dropping a suspension of sporidia into the terminal leaf-spirals was not very successful.

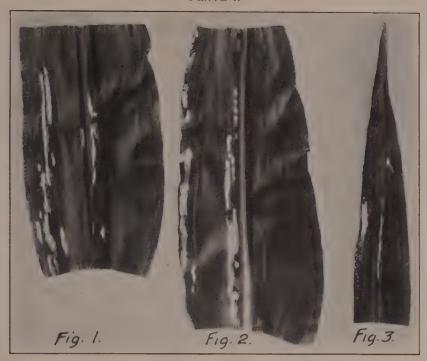
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- Plate IA. Chlorotic symptoms of corn-smut infection on the leaves.
- Figs. 1 and 2. Portion of a leaf showing large yellow blotches with occasional dark red spots.
- Fig. 3. Tip of leaf showing small yellow blotches and a yellow streak along the midrib.
 - Plate IB. Chlorotic symptoms of corn-smut infection on the leaves.
- Figs. 1 and 2. Portion of a leaf showing characteristic darkened areas and yellow spots; b, a small boil.
- Fig. 3. Portion of a leaf showing a series of small yellow spots along the midrib and yellow streaks along the margin.

PLATE I.



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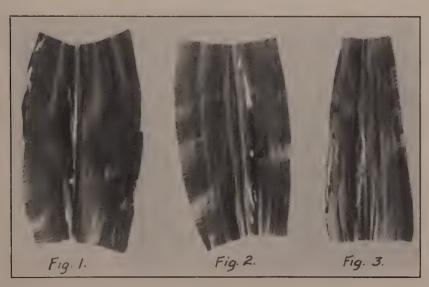


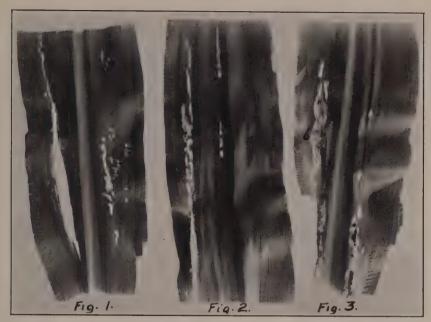
Plate IIA. Chlorotic and necrotic symptoms of corn-smut infection on the leaves.

Figs. 1 to 3. Portions of leaves showing characteristic yellow and red blotching and torn necrotic areas; b, a small boil.

Plate IIB. Necrotic symptoms of corn-smut infection on the leaves.

Figs. 1 to 3. Portions of a leaf showing torn necrotic areas.

PLATE II.



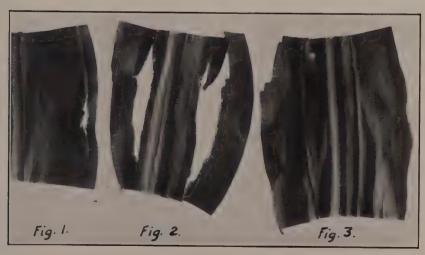


Plate IIIA. Infection on the leaf of a sweetcorn plant, var. Golden Bantam, treated by dropping a sporidial suspension into the terminal leaf-spiral when the plant was 15 inches tall with seven leaves unfolded.

- Plate IIIB. Infection of sweetcorn, var. Golden Bantam, obtained by dusting chlamy-dospores into the terminal leaf-spiral.
- Fig. 1. Infected upper leaf and tassel of a plant treated when 13 inches tall with six leaves unfolded.
- Fig. 2. The next lower leaf of the same plant showing infected areas.

Plate IIIC. Infection on the upper leaf and the tassel of a dentcorn plant, var. Reid's Yellow Dent, strain Iodent No. 25, treated by dropping a sporidial suspension into the terminal leaf-spiral when the plant was 14 inches tall with six leaves unfolded.



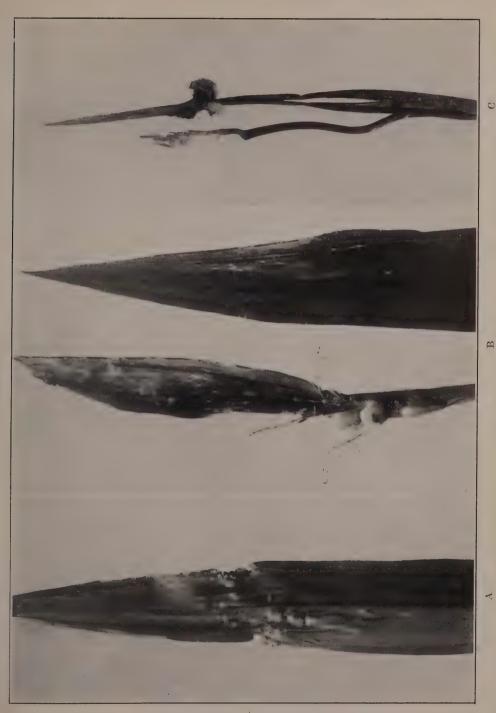


Plate IV. Infection on the tassel and upper leaves of a denteorn plant, var Reid's Yellow Dent, strain Iodent No. 25, treated by dropping a sporidial suspension into the terminal leaf-spiral when the plant was 16 inches tall with seven leaves unfolded.





Plate V. Infected tassel of plant shown on Plate IV.

PLATE V.



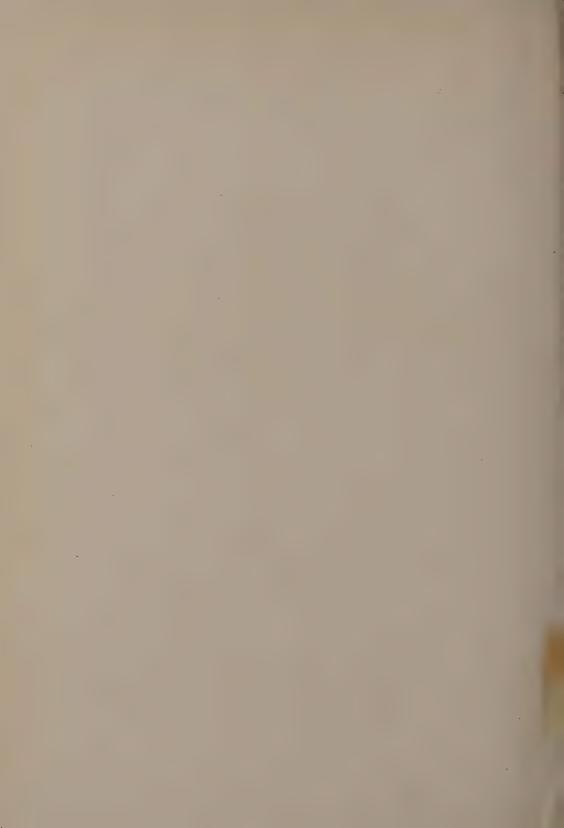


PLATE VI.

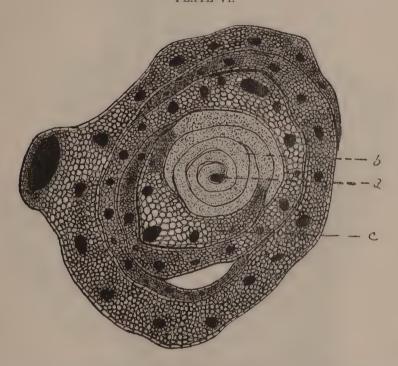


Plate VI. Diagram of a portion of a transverse section through the growing tip of a corn plant five inches tall with three leaves unfolded.

- a. Growing tip.
- b. Firmly packed overlappings of the innermost leaf of the terminal spiral.
- c. Next older leaf of the spiral.

PLATE VII.

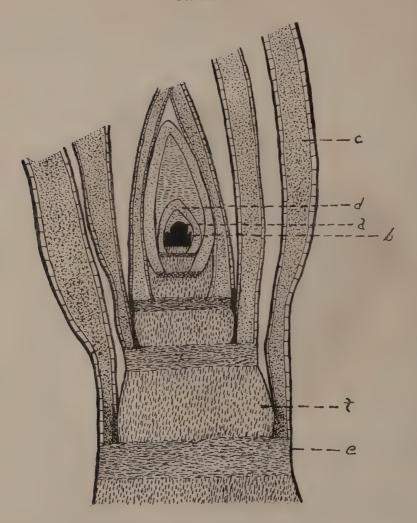


Plate VII. Diagram of a portion of the longitudinal section through the growing tip of a corn plant five inches tall with three leaves unfolded.

- a. Growing tip.
- b. Leaf primordium.
- c. First leaf of plant.
- d. Fifth leaf of plant.
- e. First node.
- f. First internode.



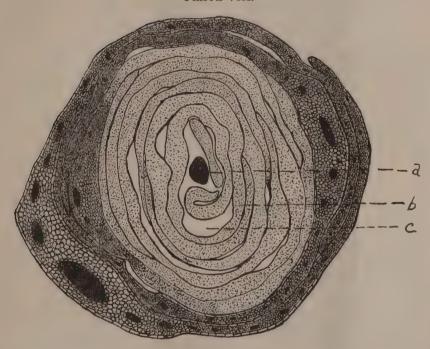


Plate VIII. Diagram of a portion of a transverse section through the growing tip of a corn plant 15 inches tall with the seventh leaf unfolded.

- a. Growing tip.
- b. Overlapping of the innermost leaves of the terminal spiral.
- c. Interspace between the overlappings of the leaves.

PLATE IX.

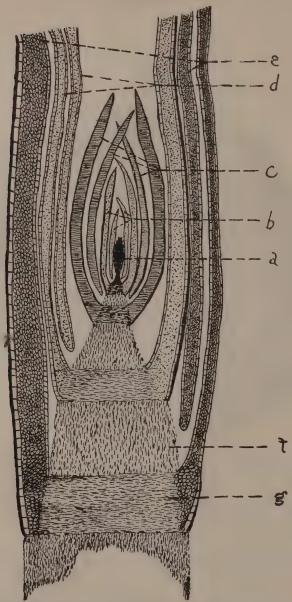


Plate IX. Diagram of a portion of a longitudinal section through the growing tip of a corn plant 15 inches tall with the seventh leaf unfolded.

a. Growing tip (tassel).

b. Overlappings of the innermost leaf.
c. Overlappings of the second oldest leaf.
d. Overlappings of the third oldest leaf.
e. Overlappings of the fourth oldest leaf.
f. Interrode

- f. Internode.
- g. Node.

THE INFLUENCE OF LAUNDERING ON SOME COTTON AND LINEN FABRICS

MARION GRIFFITH, THELMA SPRAGUE and VERA BERG with RACHEL EDGAR

From the Chemical Laboratory of Iowa State College

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The factors influencing the service of a fabric are the construction of the fabric and the treatment the fabric receives in use and cleansing. The factor fabric construction has been studied, in the case of eleven fabrics listed in Table I, as to the effect of repeated laundering, that is, washing and ironing without soiling, upon the thickness, weight, inorganic content and dry and wet breaking strengths. The effect of moist heat at 120°C. and 20 pounds pressure on the dry warp breaking strength of unbleached, bleached, and mercerized cotton sheeting and bleached linen sheeting was studied because sheeting is sterilized under these conditions in hospital practise.

Experimental A list of the fabrics laundered is given in Table I.

TABLE I.

		,	Price per
	Fabrics .	Construction	yd.s
A.	Unbleached cotton sheeting	Plain weave	\$0.20
B.	Bleached cotton sheeting	Plain weave	0.22
C.	Mercerized cotton sheeting	Plain weave	0.72
D.	Unbleached linen sheeting	Plain weave	0.71
E.	Bleached linen sheeting	Plain weave	0.69
F.	Linen-finished cotton, shirting	Plain weave	0.35
G.	Permanent-finished cotton shirting	Plain weave	0.35
H.	Silver-bleached linen table damask	5-Leaf satin, snow drop pattern	1.04
1.	Bleached linen table damask	5-Leaf satin	1.75
J.	Mercerized and schreinerized cotton table damask	5-Leaf satin, stripe pattern	0.43
K.	Permanent-finished and schreinerized cotton table damask	5-Leaf satin, stripe pattern	0.60

The table damasks had backgrounds of warp-face satin and Jacquard figure weaves of filling-face satin on the right surface with the order reversed for the other surface.

Table II is an analysis of the new and of the once laundered fabrics.

There were cut from each fabric four two-yard lengths which were hemmed before being washed in laundry nets for 1,100, 150 and 200 times. The fabrics were laundered at the College Laundry in an American Laundry Machine by a method similar to that used by commercial laundries. The fabrics, in the proportion of 60 pounds of fabrics to 40 gallons of water and 1 pound of powdered soap, were washed for 15 minutes at 140°F. Then two quarts of bleach (10 pounds of bleaching powder and 30 pounds of soda ash to 40 gallons of water) were added and the washing continued for 10 minutes. The fabrics were given two rinses at 140°F. followed by

TABLE II.

Yarn count	Builliu	Hanks	21.3	20.4	40.0	15.9	18.6	13.2	13.2	11.5	20.7	14.5	17.7
Yarn	Warp	Hanks	17.9	21.5	34.2	11.7	16.7	13.8	13.8	13.4	20.4	17.7	22.5
Yarns per inch	2ailliA		71.7	65.3	105.7	48.2	64.7	45.0	44.0	51.1	0.99	42.0	78.6
Yarns	qısW		67.5	75.1	109.2	48.7	67.8	52.0	52.0	61.3	77.0	61.2	7.67
Shrinkage	Filling	Pet.	6.3	+2.7	6.0	7.1	2.7	2.1	2.8	+4.2	+0.5	+0.2	6.0
Shri	Warp	Pet.	8.9	5.4	5.4	5.4	6.3	3.6	3.0	5.4	2.2	7.2	2.7
	Ąsy	Pet.	1.45	0.07	0.00	1.51	1.30	0.03	0.03	0.28	0.14	0.00	0.39
	toritxe retract	Pet.	4.3	1.6	0.2	4.3	0.4	0.4	0.0	2.1	2.2	0.5	0.0
hickness	ьэтөрпивл	Inches	0.0136	0.0113	0.0079	0.0136	0.0106	0.0144	0.0134	0.0154	0.0104	0.0156	0.0139
Thie	WeW	Inches	0.0128	0.0097	0.0068	0.0085	0.0088	0.0104	0.0108	0.0101	0.0063	0.0074	0.0079
Weight per	Гаппдетед	0		4 89	3 79	4.52	4 45	505	20.00	5,35	5 05	4.32	5.43
Weight	МеЖ	Ounces	5 00	4.81	2 80	78.4	477	1 Y	700 M	6.08	1 5 06	4 46	5.60
	Fabric		V	1 0	٦٢		1	9 6	ا کا	ı E	1	4 H	× ×

TABLE II—(Continued.)

tdgi:	ov-dig	luə.	ng		24.40	24.95	23.39	25.46	33.54	22.18	20.38	22.86	33.90	24.44	21.61
		Filling	Laun- dered	Ibs.	141	121	113	125	160	58	55	68	65	40	75
	4	Fill	New	Ibs.	145	143	115	140	170	61	26	81	73	44	78
fabric	Wet	Warp	Laun- dered	l lbs.	133	119	95	146	188	500	50	87	93	57	99
Breaking strength of fabric		M	New	lbs.	149	134	112	191	213	61	48	106	103	67	65
king str		Filling	Laun-	lbs.	58	54	37	44	43	56	58	62	7.1	33	70
Breal	Dry	E	New	lbs.	59	62	38	20	7.2	58	56	58	78	47	29
		Warp	Laun- dered	lbs.	51	48	37	59	70	58	51	69	06	54	48
			New	lbs	63	500	53	74	800	54	51	81	94	62	54
	ոջեր	eį .	ાંગુલ	Inches	1.12	1.01	1.02	1.84	1.81	1.03	0.93	1.51	1.15	0.88	0.95
. ar	u	Direction			I	H	-	H	1	T	L	T	T	T	Ĥ
f yarn Filling	u	Deviatio		cent Per-	19	=	14	100	16	0.1	13	10	61	10	12
inch or		Number			10	19	20	16	14	12	12	13	10	23	15
Twists per inch of yarn		oita	Direc		T	H	1-	ī	L	Н	I	L	1	7	F
Twis	u	moitsived.		cent Per-	13	17	0	00	12	7	6	2	10	050	22
		Number			21	20	96	10	13	14	15	18	6	21	19
Falbrie				\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	1 2	10	a A	2	E	*	II	1	, -	×	

three cold rinses with a trace of Aniline Blue in the last rinse. All water used was of zero hardness. The fabrics were ironed at 340°F.

The average thickness in inches of a fabric was determined from 10 measurements taken at different parts of the fabrics (exclusive of fabric within 6 inches of the selvage) by means of an automatic micrometer which exerted a constant pressure on a circle of fabric $\frac{3}{2}$ inch in diameter (1).

Yarns were drawn in the new fabrics and in the two-yard lengths for laundering outlining two test specimens each of 4 inches in length and of the entire width of the fabric. These specimens were cut from the fabrics after 0, 1, 100, 150 and 200 launderings and were conditioned and weighed. The average of these two weights was taken as the basis of calculation for the weight in ounces per square yard of fabric (2).

The ash analyses were made in triplicate on approximately 5 gram fabric samples heated to constant weight at 105°C. and ashed to constant

weight at a dull red heat in an electric muffle furnace.

The water extract analyses were made in triplicate on approximately 5 gram fabric samples heated to constant weight at 105°C. The sample of fabric was boiled one hour in 500 cm.³ distilled water and dried to constant weight at 105°C. Weighings for the water extract and ash determinations were made with a tare.

Breaking strength was determined by means of the Scott Universal Tester on conditioned and wet (soaked in distilled water for 5 minutes and drained) fabrics according to the $1 \times 1 \times 3$ inch grab method (5). Specimens of the fabric 6 inches long and 4 inches wide (10 in the warp direction and 10 in the filling direction) were cut for each test and the dry specimens were conditioned. No specimens were taken within 8 inches of the selvage. The testing machine jaws (the back jaws measuring 2 inches and the front jaws 1 inch) were clamped 3 inches apart in the 6 x 4 inch fabric specimen, making sure that both sets of jaws held the same yarns in the direction of strain. The specimen was strained to the breaking point, the pulling jaws regulated at a speed of 12 inches per minute. The strength-weight factor (4) was calculated for the new fabrics as follows:

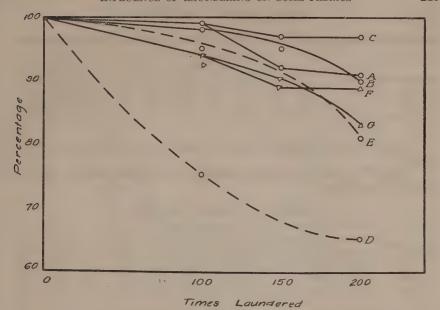
Strength-weight factor = Pounds warp breaking strength + pounds filling breaking strength

Fabric weight in ounces per square yard

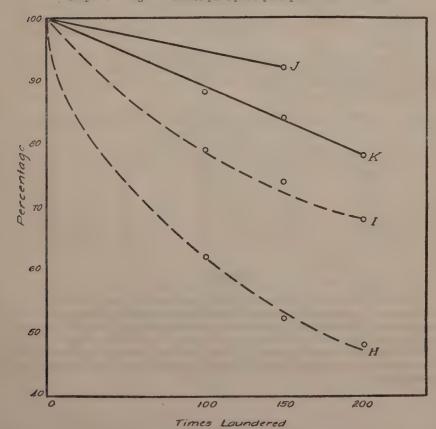
Dry breaking strength, weight and yarn count were determined after conditioning the fabrics and yarns for 4 hours at 65 ± 3 percent relative humidity and $70^{\circ}\pm3^{\circ}F$. The humidity was read from a hygrodeik placed three feet in front of an electric fan. The hygrodeik was calibrated by the chemical method (3).

The breaking strength specimens for the moist heat test at 120°C. and 20 pounds pressure were suspended from a frame above the water in an electrically controlled autoclave for 20, 35, 50, 65, 75, 90 and 100 hours. This frame and the specimens were removed for a few minutes every 5 or 10 hour period when the water in the autoclave was replenished with boiling water. The time of heating reported is the actual time of heating at 120°C. After completion of the heating period the specimens were dried, conditioned and tested.

Table III gives the thickness of fabrics as percentage of the thickness of the once laundered fabrics.



Graph I. Weight in ounces per squard yard plain weave fabrics.



Graph II. Weight in ounces per square yard damasks.

TABLE III. THICKNESS AS PERCENTAGE OF ONCE LAUNDERED FABRIC.

	Fabrics										
Launderings	A	B	C	D J	E	F	G	H	I	J	K
100	88	95	101	78	96	99	100	83	105		107
150	87	99	106		89	99	99	82	111	104	101
200	86	90	100	63	89	96	92	69	110		108

Graphs I and II show the change in weight of the fabrics due to laundering.

Table IV gives the inorganic content of the fabrics after 1, 100, 150 and 200 launderings.

TABLE IV. PERCENTAGE ASH.

	Fabrics											
Launderings	A	В	C	D	E	F	G	H	Ι	J	K	
1	0.23	0.07	0.10	0.73	0.16	0.07	0.07	0.22	0.13	0.08	0.13	
100	0.25	0.23	0.30	0.30	0.21	0.27	0.23	0.24	0.19	-	0.27	
150	0.38	0.36	0.35		0.25	0.37	0.29	0.32	0.27	0.53	0.36	
200	0.44	0.44	0.34	0.36	0.28	0.48	0.36	0.36	0.33		0.43	

Graphs III and IV show the change in average (warp and filling) dry breaking strength of the fabrics due to laundering. Graphs V and VI show the change in average wet breaking strength of the fabrics due to laundering.

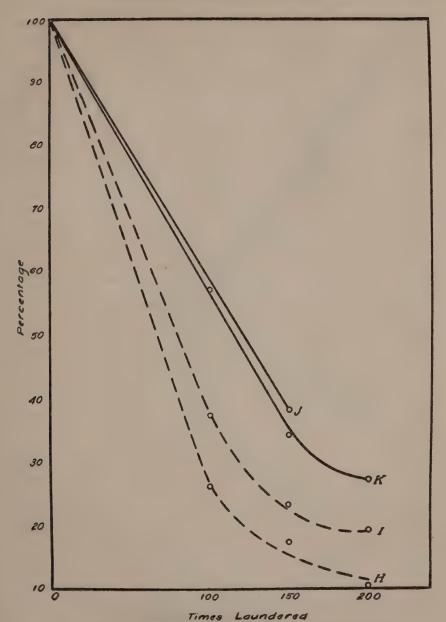
Table V gives the dry warp breaking strengths of the unbleached, bleached, and mercerized cotton and of the bleached linen sheetings after 20, 50, 65, 75, 90, and 100 hours exposure to moist heat at 120°C. and 20 pounds pressure.

TABLE V. DRY WARP BREAKING STRENGTH AS PERCENTAGE OF NEW

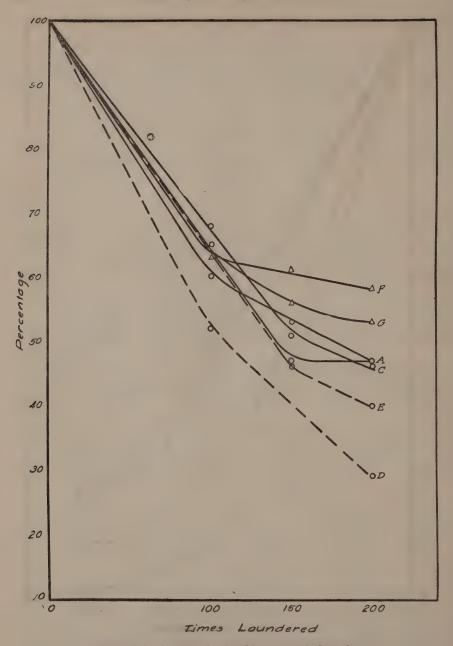
	Fabrics								
Hours at 120° C	A	В	C	E					
20	68	71	57	47					
35	65	62	66	50					
50	60	62	60	42					
65	70	57	72	52					
75	73	59	62	50					
90	. 56	50	47	38					
100	63	66	57	41					
Average	65	61	60	46					

Summary

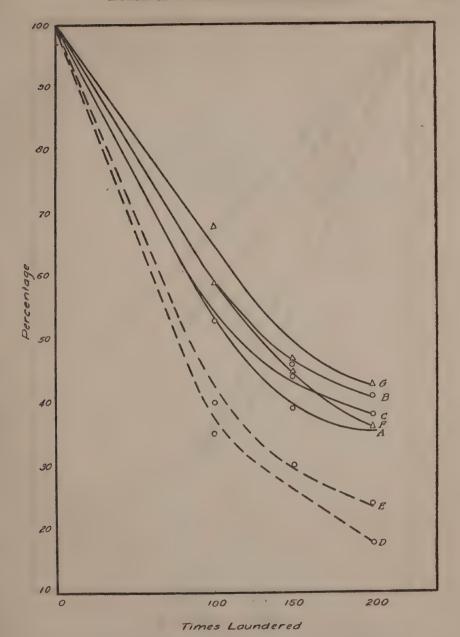
Eleven fabrics representing table, costume and bed fabrics and of bleached and unbleached linen or cotton and of special-finished cotton were studied as to the effect of laundering upon the thickness, weight, inorganic content and dry and wet breaking strengths. The effect of moist heat at 120°C. and 20 pounds pressure on the breaking strength of unbleached, bleached, and mercerized cotton sheeting and bleached linen sheeting was determined.



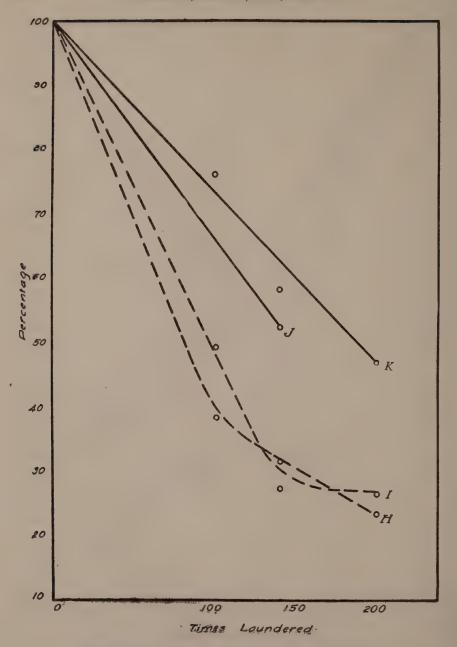
Graph III. Average dry breaking strength plain weave fabrics.



Graph IV. Average dry breaking strength damasks.



Graph V. Average wet breaking strength plain weave fabrics.

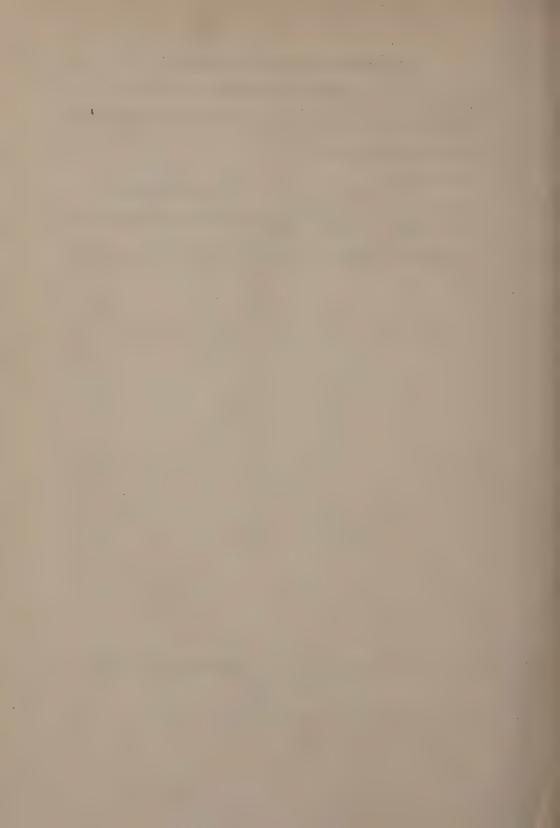


Graph VI. Average wet breaking strength damasks.

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THE DIRECT SYNTHESIS OF OPTICALLY ACTIVE COMPOUNDS AND AN EXPLANATION OF THE ORIGIN OF THE FIRST OPTIC-ALLY ACTIVE COMPOUND¹

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A number of attempts have been made to prepare directly an optically active compound. So far as we know, no one has succeeded in producing an asymmetric synthesis without the intervention of optically active compounds. The reason for the lack of success is simple and well known. If we confine ourselves, for the sake of convenience, to optically active compounds having one carbon atom as the center or seat of optical activity, we can formulate the necessary steps for asymmetric synthesis as follows. (C represents carbon; "a", "b", "c", and "d" represent unlike elements or groups; and, "c", "c" and "c", "are alike).

$$e^{2} - C - b - c - b - c - c$$

The compound C a,b,c¹,c² is symmetrical and without optical activity. However, when treated with an element or compound "d—d" so that one of the "c's" is replaced by a "d" we get Ca,b,c,d. This compound is asymmetric and should be optically active. As a matter of fact, compound Ca,b,c,d formed in this way is inactive. Its inactivity is due to the simultaneous replacement of "c¹" and "c²", respectively, by "d" in two molecules to give C a,b,c¹,d and Ca,b,c²,d. Each of these compounds is optically active to the same degree but in opposite directions so that a mixture of the two, known as a raceme, is optically inactive by external compensation. The reason for the simultaneous formation of the optical opposites in supposedly equal amounts lies in the symmetry of Ca,b,c¹,c² and the equal opportunity of replacing "c²" or "c²" by "d". Both optically active forms, Ca,b,c¹,d and Ca,b,c²,d possess equal energies as a result of which their formations in a chemical reaction are equally probable.

formations in a chemical reaction are equally probable.

Actually, however, they are *not always* formed in equal amounts. If we start with a solution of Ca,b,c^1,c^2 containing n molecules, the number n may sometimes be even and sometimes odd. When n is an odd number then

²The author has regularly presented this material in lectures at Iowa State College, where such presentation is pertinent to a discussion of optical activity. A semi-popular abstract of it by the author has appeared in the *Chemical Bulletin* 12, 133 (1925). We make no claim for the novelty of the ideas expressed here, but we are not familiar with like material published elsewhere.

the resulting product² must have one molecule of either Ca,b,c¹,d or Ca,b,c²,d in excess. If we arbitrarily designate the C a,b,c¹d molecule as dextro, the other molecule, Ca,b,c²,d is its optically opposite levo form; and if a sufficiently large number of reactions is carried out between an indefinite number of Ca,b,c¹c² and ''d—d'' molecules then 50% of the time a racemic mixture is formed, 25% of the time there is an excess of one dextro molecule, and 25% of the time there is an excess of one levo molecule.

We have here considered but one of the cases when there would be present an excess of either optically active form, and this depends on the presence in the solution of an odd number of molecules. However, the formation of optically active forms is possible even in those cases where the number of molecules, n, is even. This is particularly true when one starts with highly dilute solutions containing a small number of molecules. (The limiting case is a solution having but one molecule of C a,b,c¹c². The product (Ca,b,c,d) must be optically active and is either the dextro or the levo form.) With dilute solutions of Ca,b,c¹c² having 2 or 4 or 6, etc., molecules, the number is so small that the so-called laws of chance and probability do not hold. As a consequence, if we start, for example, with a solution having but 2 molecules it is quite possible that these 2 molecules might be converted to 2 molecules of the dextro form or 2 molecules of the levo form. Of course, there is a greater opportunity for the formation of the optically inactive raceme.

The possibility of getting a complete conversion of n molecules (where n is either even or odd) to the dextro or to the levo form obviously decreases with an increase in the number of molecules. Despite this progressive decrease in possibility with an increase in the number of molecules we would, sometime or other if a sufficient number of experiments were performed, get a complete conversion to the dextro or to the levo form in accordance with the statistical theory of probability. The number of experiments necessary to reach this fortuitous complete conversion to an optically active

form would be extreme, but not infinite³.

Also, with an even large number, n, of molecules there might be present a number of optically active molecules ranging from 2 to n. Obviously, the chance for a slight excess of optically active molecules (either dextro or levo) is decidedly greater than the limiting case where all of the molecules are dextro or levo.

It is apparent from these considerations that the chemist actually does effect unwittingly direct asymmetric syntheses. However, he has no means at present of testing experimentally the direct formation of a *small* number of molecules of an optically active compound. One can imagine that in the somewhat remote future an apparatus and technique of sufficient delicacy might become available for this purpose. Until that time comes, if indeed it ever arrives, there is always the possibility of that rare accident when a sufficient concentration of optically active molecules will be formed to be

²The assumption is made here that all of the reactant molecules give a corresponding number of molecules of product. If the reaction is reversible or if the reaction is incomplete for any reason, the mathematical development of the principle expounded here is the same. The subsequent development of even numbered molecules in the following paragraph is also sound even though molecules react only two at a time or in even numbers—an idea that has no basis in experimental fact of which we are aware.

measurable by our present facilities. The possibility of such a remarkable observation being noted is rendered even more remote by the fact that chemists, very wisely, would not take the trouble to examine such reactions for optical activity. Also, if noted there would be a pardonable and under-

standable reluctance to publish a finding of this type³.

The same philosophical application of the statistical theory of probability gives us an explanation of the first optically active compound. We know that with a single optically active molecule it is possible to explain the origin of the myriad of optically active forms known in nature. Given this one optically active molecule we can, by an application of one of the methods proposed by Pasteur for the resolution of racemates, resolve all racemates by a chain series of reactions⁴. The difficulty lies in accounting for the first optically active molecule. What follows is a proffered explanation of the origin of such a molecule or of such molecules.

If we arbitrarily assume that the simpler thermally stable elements gave rise in the course of a cooling process to simple thermally stable inorganic compounds and that from these and the elements in turn the simpler thermally stable organic compounds were formed, we have a gradual process for the formation of simple or complex organic compounds. If this formation of compounds took place very slowly, there is a possibility that

This moleule of optically active base would then find its way, in the course of time, to a racemic acid and give one molecule of a salt and one molecule of a free optically active acid. This molecule of optically active acid would soon find itself not alone, inasmuch as another molecule of optically active acid would come from the hydrolysis or dissociation of the originally formed salt(s). A difficulty enters here, but it does not remain for long. It is this: the two molecules of optically active acid might be optical opposites and so form a raceme. But, there is an equal chance that they would be of the same type, either dextro or levo. An increase of this type would continue, given sufficient time, for the free molecule of optically active base is presumably going its rounds in the resolution of racemic acids.

³It is interesting to reflect on these possibilities with a host of other reactions and phenomena. For example, it is conceivable that under conditions where phenol on bromination gives chiefly a mixture of o-bromophenol and p-bromophenol we might get sometime all m-bromophenol. The publication of such a result would carry with it an extraordinary embarrassment for one who would venture to check the experiment! It would not be surprising if a few (an astonishingly small number) of the abnormal, non-duplicable results observed by some investigators were not due to such a happy or unhappy "accident" postulated by the statistical theory of probability.

^{&#}x27;By this, we do not mean of course that the one optically active molecule would act as a seed in a given solution to convert all of the other inactive molecules contained therein to the dextro or levo form. What we do mean is that the one active molecule, let us assume it to be a dextro acid, would find its way (through one means or another like infiltration, high volatility, air currents, etc.) to a solution of a racemic base. (The problem of transportation becomes simpler if our optically active molecules are gases.) As a result of the reaction between the dextro acid and the racemic base we would get one molecule of the salts formed from the dextro acid and either the dextro base or the levo base. In this manner a molecule of either the levo base or dextro base would be free.

For convenience sake we are omitting consideration of the possible prior formation of optically active inorganic compounds. Furthermore, the problem becomes more simple should it ever be found that an element (because of an asymmetric arrangement of electrons) can be optically active. In such an hypothetical event one might go beyond the element to the electron or sub-electron.

one molecule of Ca,b,c,d was formed at first. This one molecule must have been optically active, either dextro or levo, and it would suffice to explain

the resolution of the racemates which were formed subsequently.

There are other possibilities. Instead of one molecule of C a,b,c,d forming at first, a small number of molecules of C a,b,c¹d and C a,b,c²,d might have formed. With this small number of molecules there would be the chance for an excess of either C a,b,c¹d or C a,b,c²,d molecules. The excess of either one of these optically active forms, even to the minimal excess of one molecule, would again provide the means for the resolution of racemates.

Finally, there is the possibility that myriads of molecules of C a,b,c¹d and C a,b,c²,d were formed at one time, either with or without gradual cooling and under any set of conditions6. In this event, we might have an odd number of molecules formed and the odd molecule must have been optically active. Or, if all the molecules of C a,b,c¹d and C a,b,c²d were formed at one time, and if the total number of these molecules was an even number, then there is the possibility again (as developed previously) that there would be an excess of two or more optically active molecules.

Explanations of this type find a basis of support solely on the statistical theory of probability. As with many other phenomena, there is the possibility that the first optically active compounds may have had their simultaneous origin in several ways, only one of which has been discussed.

SUMMARY

By the application of the statistical theory of probability it has been shown that direct asymmetric syntheses may frequently take place. An explanation has been offered for the origin of the first optically active compound or compounds.

[&]quot;The development of this idea would apply to the most complex molecules and to the most complex aggregates of such molecules. Again, for the sake of convenience, we are omitting any consideration of meso forms which are optically inactive by internal compensation.

A TORSION PROBLEM IN CURVILINEAR COORDINATES¹

BY E. W. ANDERSON AND D. L. HOLL.

From the Department of Mathematics, Iowa State College.

Accepted for publication March 14, 1929.

- 1. Introduction: Suppose that a uniform isotropic rod is fixed at one end, and that any two sections of the rod at unit distance apart are twisted through an angle τ relative to each other. We shall assume that all elements of the rod of equal length are strained in exactly the same way. This means that the stresses and strains are independent of the length of the rod. It is further assumed, as did Saint-Venant², that the shearing stresses over any cross section are reduced to the effect of a pure couple, and at the same time give no action on the sides of the prism, that is the boundary stress is a tangential stress.
- 2. Equations of Equilibrium. The notations employed are those used by Prescott³ and are defined as follows:

x, y, z, rectangular coordinates of a point of prism, with the Z axis along the axis of the prism,

u, v, w, displacements in X, Y, Z directions, respectively,

P₁, P₂, P₃, unit normal stresses on elements perpendicular to X, Y, Z, axes, respectively,

S₁, S₂, S₃, unit tangential stresses on similar elements, μ_{\bullet} modulus of rigidity.

$$m = \frac{\mu}{1-\sigma}$$
, where σ is Poisson's ratio,

7. angle of twist per unit length.

For small distortions, within which Hooke's law is valid, the displacements and stresses are given by

$$u = -\tau yz,$$
 $v = \tau xz,$ $w = f(x,y),$ (1)
 $P_1 = P_2 = P_3 = S_3 = 0, S_1 = \mu \left(\frac{\partial w}{\partial v} + \tau x \right),$

$$S_2 = \mu \left(\frac{\partial W}{\partial x} - \tau y \right) . \tag{2}$$

¹Thesis presented to Graduate School of Iowa State College by Mr. Anderson for the degree of Master of Science in Applied Mathematics.

²Saint-Venant, De la torsion des prismes. Mem. des Savants etrangers, Bd. 14, S. 233, 1855.

²J. Prescott, Applied Elasticity, p. 134, Longmans, Green and Co., 1924.

From the fundamental equations of elastic equilibrium are obtained the equations

$$\frac{\partial S_2}{\partial x} + \frac{\partial S_1}{\partial y} = 0, \tag{3}$$

$$\frac{\partial S_1}{\partial x} - \frac{\partial S_2}{\partial y} = a \text{ constant.}$$
 (4)

Equation (3) is satisfied if

$$\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} = \nabla^2 w = 0, \tag{5}$$

and the constant in (4) is $2\mu\tau$.

At the surface of the prism, the usual requirement is that the direction of the resultant shearing stress must be tangential to the contour of the cross section. Hence it is necessary that the boundary should be a shear line, that is,

$$\frac{\mathrm{dy}}{\mathrm{dx}} = \frac{\mathrm{S_1}}{\mathrm{S_2}} \tag{6}$$

This boundary condition is simplified, if w is the real part of an analytic function $\Phi = w + i\Psi$ of the complex variable Z = x + iy. Hence

$$\frac{\partial \Psi}{\partial y} = \frac{\partial w}{\partial x}, \qquad \frac{\partial \Psi}{\partial x} = -\frac{\partial w}{\partial y}, \tag{7}$$

and (6) becomes

$$\mathrm{d}\Psi = \frac{\tau}{2}\,\mathrm{d}(\mathrm{x}^2 + \mathrm{y}^2),$$

or

$$\Psi = \frac{\tau}{2} (x^2 + y^2) + a \text{ constant.}$$
 (8)

Equation (5) becomes
$$\nabla^2 \Psi = 0$$
. (9)

The family of shear lines is given by (8). For a simply connected boundary, no loss of generality is incurred if the constant of (8) is taken equal to zero for the boundary of the prism, since Ψ occurs in subsequent computations only through its derivatives. That a solution of (9), subject to the condition of (8) exists, may be shown by an application of Green's theorem to the line integral of the tangential derivative of (8) around the contour. Equation (9) results.

Taking moments about the origin, the torque of the shearing stresses is

$$Q = \iint (xS_1 - yS_2) dxdy$$

$$= u\tau I - u \iint \left(x \frac{\partial \Psi}{\partial x} + y \frac{\partial \Psi}{\partial y} \right) dxdy, \tag{10}$$

where I is the polar moment of inertia of the section, and the integration extends over every element of area within the contour.

3. The Conformal Transformation. The prism under consideration is one of symmetrical cross section bounded by arcs of two orthogonal parabolas whose foci are at the origin, and their latera recta lie on the Y axis as shown in Fig. 1. The solution is effected by a conformal transformation $W^2 = 2Z$, which maps the section of Fig. 1 upon the rectangle of Fig. 2.

The relation

$$x + iy = Z = \frac{1}{2} W^2 = \frac{1}{2} (a + i\beta)^2,$$
 (11)

gives

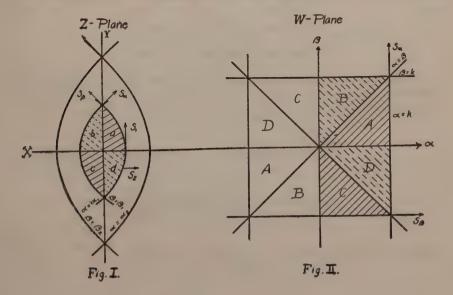
$$x = \frac{a^2 - \beta^2}{2}, y = a\beta. \tag{12}$$

These equations yield the two families of orthogonal parabolas,

$$y^2 = a^4 - 2a^2x$$

 $y^2 = 2\beta^2x + \beta^4$, (13)

where a and β are the parameters for the W plane. Fig. 2 shows graphically what may be shown analytically, that the section (a, b, c, d) of the Z



plane maps twice into the square on the W plane. The central symmetry further affords the possibility of studying the sections (A, B, C, D) of the W plane in any of the four positions in which they are contiguous.

Equation (9) remains invariant under transformation (11), while the right member of (8) becomes $\tau/8$ $(a^2 + \beta^2)^2$. The problem then is to deter-

mine Ψ such that

$$\nabla^2 \Psi = 0$$
, at every point of cross-section, (14)

and

$$\Psi = \tau/8 (a^2 + \beta^2)^2, \text{ on the contour.}$$
 (15)

4. Solution of Ψ . We may assume a solution of (14) in the form

$$\Psi = \Sigma_{\rm m} \left[f_{\rm m}(a) \cos m\beta + F_{\rm m}(\beta) \cos ma \right], \tag{16}$$

where $m = 1, 3, 5, 7, \dots$

Then

$$\nabla^2 \Psi = \Sigma_{\mathbf{m}} [\mathbf{f}_{\mathbf{m}}''(a) - \mathbf{m}^2 \mathbf{f}_{\mathbf{m}}(a)] \cos \mathbf{m} \beta$$

$$+ \Sigma_{\mathbf{m}} [\mathbf{F}_{\mathbf{m}}''(\beta) - \mathbf{m}^2 \mathbf{F}_{\mathbf{m}}(\beta)] \cos \mathbf{m} a$$

$$= 0.$$
(161)

In order that (16^1) may vanish identically for all values of α and β , the coefficients of the cosine terms must be zero. Hence

$$f_m'' - m^2 f_m = 0$$
, $F_m'' - m^2 F_m = 0$,

and

$$f_m(a) = A_m \cosh ma + B_m \sinh ma$$
,

$$F_m(\beta) = C_m \cosh m\beta + D_m \sinh m\beta$$
.

In view of the double symmetry in a and β , the function Ψ must be restricted to even functions of these variables and the hyperbolic sine terms are thus inadmissable solutions. Equation (16) takes the form

$$\Psi = \sum_{n=0}^{\infty} \left[A_n \cosh(2n+1) \frac{\pi^a}{2k} \cos(2n+1) \frac{\pi^\beta}{2k} + C_n \cosh(2n+1) \frac{\pi^\beta}{2k} \cos(2n+1) \frac{\pi^a}{2k} \right], \tag{17}$$

where m is replaced by $(2n+1)\frac{\pi}{2k}$, and $n=0, 1, 2, 3, \dots$.

The coefficients A_n and C_n are determined from the boundary condition (15). The particular parameter values for the contour in question may now be taken as $a = \pm k$ or $\beta = \pm k$. The problem then is to represent the function $\Psi = \tau/8(a^2 + \beta^2)^2$ for $a = \pm k$ by a Fourier's series of cosines of β where β ranges from (-k) to (+k).

Here

$$\Psi = \tau/8(k^2 + \beta^2)^2 = \frac{2k^4\tau}{\pi^4} \left(\theta^2 + \frac{\pi^2}{4}\right)^2$$

$$= \sum_{n=0}^{\infty} b_n \cos(2n+1)\theta, \qquad (18)$$

where

$$\theta = \frac{\beta \pi}{2k}$$
, n = 0, 1, 2, 3, 4,

and

$$b_{n} = \frac{2}{\pi} \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \left(\theta^{2} + \frac{\pi^{2}}{4} \right)^{2} \cos(2n+1)\theta d\theta$$

$$= M_n \sin (2n+1) \frac{\pi}{2},$$

with

$$M_{n} = \frac{\pi^{3}}{2n+1} - \frac{16\pi}{(2n+1)^{3}} + \frac{96}{\pi(2n+1)^{5}}.$$
 (19)

The expansion of Ψ on boundaries $a = \pm k$ valid on the given range of β , is

$$\Psi = \frac{2k^4 \tau}{\pi^4} \sum_{n=0}^{\infty} M_n \sin (2n+1) \frac{\pi}{2} \cos (2n+1) \frac{\pi \beta}{2k}.$$
 (20)

Since the right members of (17) and (20) are identities in β when $a = \pm k$, the coefficients A_n are

$$A_{n} = \frac{2k^{4}\tau M_{n} \sin (2n+1)\pi/2}{\pi^{4} \cosh (2n+1)\pi/2} . \tag{21}$$

By symmetry $A_n = C_n$.

Hence

$$\Psi = \frac{2k^{4}\tau}{\pi^{4}} \sum_{n=0}^{\infty} \frac{M_{n} \sin(2n+1)\pi/2}{\cosh(2n+1)\pi/2} \left[\cosh(2n+1) \frac{\pi a}{2k} \right]$$

$$\cos(2n+1) \frac{\pi \beta}{2k} + \cosh(2n+1) \frac{\pi \beta}{2k} \cos(2n+1) \frac{\pi a}{2k} . \quad (22)$$

This is the form of Ψ which satisfies all the prescribed conditions of the torsion problem as it is mapped on the square of dimensions 2k by 2k on the W plane.

5. Torque. To determine the torque from (10) the following relations are given:

$$x^{2} + y^{2} = \frac{1}{4} (a^{2} + \beta^{2})^{2},$$

$$dxdy = \frac{dad\beta}{h^{2}}, \text{ where } h^{2} = \left| \frac{dW}{dZ} \right|^{2} = (a^{2} + \beta^{2})^{-1}$$

$$\frac{\partial \Psi}{\partial x} = h^{2} \left(a \frac{\partial \Psi}{\partial a} - \beta \frac{\partial \Psi}{\partial \beta} \right),$$

$$\frac{\partial \Psi}{\partial y} = h^{2} \left(\beta \frac{\partial \Psi}{\partial a} + a \frac{\partial \Psi}{\partial \beta} \right).$$

By these relations, the expression for the torque is

$$Q = \frac{\mu \tau}{4} \int_{-k}^{k} \int_{-k}^{k} h^{-6} da d\beta - \frac{\mu}{2} \int_{-k}^{k} \int_{-k}^{k} \left[a \frac{\partial \Psi}{\partial a} + \beta \frac{\partial \Psi}{\partial \beta} \right] h^{-2} da d\beta$$

$$= \frac{24}{25} \mu \tau k^{8} - \mu \left[\frac{48}{35} \mu \tau k^{8} - 2 \int_{-k}^{k} \int_{-k}^{k} \Psi h^{-2} da d\beta \right]. \tag{23}$$

The first term of (23) is the moment of inertia of the section, and the bracket terms are obtained from integration by parts and employing the boundary values of Ψ .

A typical integral of (23) to be evaluated is

 $A_m \int \int (a^2 \cosh ma \cos m\beta + a^2 \cosh m\beta \cos ma) dad\beta$

which is

$$\frac{16k^2A_m}{m^2}\sin mk \left[\sinh mk - \frac{1}{mk}\cosh mk \right].$$

Finally (23) yields

$$Q = -\frac{24}{35}\mu\tau k^{8} + \frac{256\mu\tau k^{8}}{\pi^{6}} \sum_{n=0}^{\infty} \frac{M_{n}}{2n+1} \left[\tanh(2n+1) \pi/2 - \frac{2}{\pi(2n+1)} \right] = .46358\mu\tau k^{8}$$
(24)

where M_n is given by (19).

For

n>2,
$$\tanh (2n + 1) \pi/2 = 1 - \epsilon$$
, where $\epsilon < 10^{-9}$.

Thus with corrections for the terms $n=0,\,1,\,2$, the following sums may be used in making the calculation of Q to the degree of accuracy given by

(24):

Then

$$\sum_{n=0}^{\infty} \left(\frac{1}{2n+1} \right)^{p} = \left[1 - \left(\frac{1}{2} \right)^{p} \right]_{n=1}^{\infty} \left(\frac{1}{n} \right)^{p}, \text{ and}$$

$$Q = -\frac{24}{35} \mu \tau k^8 + 256 \mu \tau k^8 [.00546328 - .00097382],$$

where the last term was the error for n = 0, 1, 2. At least fifty terms would need to be summed to obtain the above accuracy, had not the sums been employd.

In view of the double area used in the integrals, the actual torque is only half that given by (24), that is

$$Q' = .23179\mu\tau k^8. \tag{25}$$

6. Shears. From (2), (7) and the relations given in section 5, the shears are

$$S_{1} = \mu \left(\tau x - \frac{\partial \Psi}{\partial x} \right) = \mu h^{2} \left[\frac{\tau}{2} \left(a^{4} - \beta^{4} \right) - a \frac{\partial \Psi}{\partial a} + \beta \frac{\partial \Psi}{\partial \beta} \right]$$
$$= \mu h^{2} \left[\frac{\tau}{2} \left(a^{4} - \beta^{4} \right) - a \frac{\partial \Psi}{\partial a} \right]$$

$$\frac{k^3\tau}{\pi^3} \mathop{\Sigma}_{n=0}^{\infty} M_n(2n+1) \frac{\sin mk}{\cosh mk} \bigg\{ \text{ a sinh macosm}\beta - \text{acoshm}\beta \text{sinma} \\$$

$$+\beta \cosh ma \sin m\beta - \beta \sinh m\beta \cos ma$$
 $\bigg\} \bigg], \qquad (26)$

$$S_{2} = \mu \left(\frac{\partial \Psi}{\partial y} - \tau y \right) = \mu \left[h^{2} \beta \frac{\partial \Psi}{\partial a} + h^{2} a \frac{\partial \Psi}{\partial \beta} - \tau a \beta \right]$$
$$= \left[-\tau a \beta \right]$$

$$+ \frac{h^2k^3\tau}{\pi^3} \sum_{n=0}^{\infty} M_n (2n+1) \frac{\sin mk}{\cosh mk} \left\{ \beta \sinh ma \cos m\beta \right\}$$

 $-\beta \cosh m\beta \sin m\alpha + a \sinh m\beta \cos m\alpha - a \cosh m\alpha \sin m\beta$ $\}$, (27)

where M_n is given by (19) and $mk = (2n + 1)\pi/2$. On the boundary where

$$a^2 = \beta^2 = k^2$$
; $S_1 = 0$,
 $a^2 = k^2$, $\beta = 0$; $S_2 = 0$, $S_1 = .745129\mu\tau k^2$. (28)

The latter values are the boundary stresses at the ends of the chord on the X axis. It is also desirable to find expressions for the stresses along the a and β arcs. In curvilinear coordinates these are

$$Sa = \mu \left[-h \frac{\partial \Psi}{\partial a} + \frac{\tau a}{2h} \right]$$
 (29a)

$$S_{\beta} = \mu \left[\frac{\tau \beta}{2h} - h \frac{\partial \Psi}{\partial \beta} \right]. \tag{29b}$$

A typical term of Ψ in (17) shows that (29a) vanishes when $\beta = k$, similarly $S_{\beta} = 0$ on $\alpha = k$. To show this, a derivative relation of (20),

which is the expansion of $\tau/8(k^2+\beta^2)^2$, makes an identity in β with the ex-

pression h $\frac{\partial \Psi}{\partial \beta}$ of (29b). Thus the bracket quantity of (29b) vanishes iden-

tically along the parameter $a = \pm k$. This merely shows that the mathematics is consistent with the original assumption that the boundary stress is tangential.

Again it may be readily shown from a typical term of Ψ that at $a = \beta = \pm k$, both S_a and S_β vanish. These are the shears at the corners occurring on the Y axis where S_1 also is zero. Hence S_2 and in fact all stresses vanish at such a corner. This is the usual result determined from the hydrodynamical analogs².

Well known theorems on harmonic functions tell us that Ψ must attain its maximum and minimum on the boundary. It may he shown that the maximum shear stress is $S_1 = S\alpha = .7451\mu\tau k^2$ which occurs at the ends of the minor chord or the boundary point nearest the axes of the prism.

7. Vertical Displacement and Warped Sections. With the aid of (7) and (17), the displacement in the Z direction, given by (1) is,

$$W = \frac{2k^4\tau}{\pi^4} \sum_{n=0}^{\infty} \frac{M_n \sin mk}{\cosh mk} \left[\sinh \beta \sin ma - \sinh ma \sin m\beta \right] , \quad (32)$$

except for a purely arbitrary constant, which would denote a rigid body translation. Along the lines $a=\pm\beta$; w=0. Also w=0 when $a=\beta=0$, and hence there is no relative displacements along the X and Y axes.

To find the concave and convex sections of the prism, both the first and

A. E. H. Love, The Mathematical Theory of Elasticity, 4th Ed., p. 51. 1927.

A. E. H. Love, The Mathematical Theory of Elasticity, 4th Ed., p. 315. 1927.

L. Prandtl, Jahresber. d. D. Math. Vereinig., Bd. 13, 1904.

A. H. Gibson, The Mathematical Properties of Fluids-A Collective Work, p. 245, 1924.

second partial derivatives $\frac{\partial w}{\partial y}$ and $\frac{\partial^2 w}{\partial y^2}$ vanish on the X axis, but $\frac{\partial w}{\partial y}$ re-

mains positive on passing to either section. Hence the section is convex in the first and third quadrants and concave in the second and fourth. Figs. 1 and 2 show the convex sections by solid lines and concave by dotted lines.

8. Comparisons for Torque and Shear. A circle having the same area

as the cross section of the prism, will have a radius $\frac{(2k^2)}{(3\pi)^{\frac{1}{2}}}$ and the torque is

$$Q_{c} = \frac{1}{2} \mu \tau \pi r^{4} = \frac{8}{9\pi} \mu \tau k^{8}$$
$$= .28294 \mu \tau k^{8}. \tag{33a}$$

An ellipse having the same minor axis k2, and the same area will have a

major axis $\frac{(16k^2)}{(3\pi)}$, and the torque is

$$Q\epsilon = \mu \tau \frac{\pi a^{3}b^{3}}{a^{2} + b^{2}} = .24756\mu \tau k^{3}.$$
 (33b)

From a number of minor observations, Saint-Venant¹ concluded that the torque of sections, which were fairly compact and with no reentrant angles, could be approximated by

$$Q_s = \frac{\mu \tau A^4}{40I},$$

where I is the polar moment of inertia and A is the area. For the prism

under consideration the area is $\frac{4k^4}{3}$ and the inertia $\frac{12k^8}{35}$ hence

$$Q_s = .23045 \mu \tau k^8.$$
 (33c)

These values are to be compared with .23179 $\mu\tau$ k⁸ given by (25).

The maximum shearing stress is $S_1 = Sa = .7541\mu_7 k^2$. To give comparisons with the above figures, for a circle,

$$S_o = \mu \tau r = \frac{\mu \tau 2k^2}{(3\pi)^{\frac{1}{2}}} = .65147 \mu \tau k^2.$$
 (34a)

¹Saint-Venant, C. R., Bd. 88, S. 142, 1879. Handbuch der Physik, Bd. VI, S. 160, 1928.

For the ellipse, of same area and same minor axis,

$$S_{\epsilon} = 2\mu\tau \frac{a^2b}{a^2 + b^2} = .74411\mu\tau k^2.$$
 (34b)

For the ellipse, of same major and minor axes,

$$S\epsilon' = 4/5\mu\tau k^2 = .80000\mu\tau k^2$$
. (34c)

Since the circle has the same tangential stress at all boundary points, the comparison of (34a) with (28) is of little import, but can be accounted for by the fact that the radius $2k^2(3\pi)^{-\frac{1}{2}}$ is much greater than the semi-minor chord $k^2/2$ of the prism under consideration.

9. Approximate Solutions. From a purely analytical consideration of equations (3) and (4), both stresses S_1 and S_2 may be expressed in terms of a new function of the variables x and y. Let $\xi(x,y)$ be such a stress function, then

$$S_1 = -\frac{\partial \xi}{\partial x}, S_2 = \frac{\partial \xi}{\partial v}.$$
 (35)

Equation (3) is satisfied identically, while (4) yields

$$\nabla^2 \xi = 2\mu\tau \quad . \tag{36}$$

The boundary condition (6) is equivalent to (8), that is,

$$\xi = \Psi - \tau/2(x^2 + y^2) = a \text{ constant or zero.}$$
 (37)

Since (37) becomes the equation of the shear lines, it follows that if $\xi(x,y) = 0$ is taken as the boundary of any cross section such that (36) yields $\nabla^2 \xi = \text{const.}$, an immediate solution of the torsion problem can be effected. Exact solutions are readily obtained for the circle, the ellipse, and the equilateral triangle by this method.

Approximate solutions sufficiently accurate for technical practice may be obtained by employing the minimal property of the "Energy of Deformation." The really useful thing about this method is that equation (36) is not solved, indeed it is only necessary to satisfy (37) choosing a function $\xi(x,y)$ such that it vanishes on the boundary and that it represents as nearly as possible the form of the shear lines over the cross section. In this matter only the experience, and known solutions can guide in the selection of the form of the function. The form of the stream lines may be inferred from the hydrodynamical analogs mentioned in section 6.

The energy² per unit volume is

A. und L. Föppl, Drang und Zwang, Bd. I, p. 101, 1924; Bd. II, p. 53, 1928.

A. und L. Föppl, Drang und Zwang, Bd. I, p. 58, 1924.

Handbuch der Physik, Bd. VI, \$16, S. 66, 1928.

J. Prescott, Applied Elasticity, p. 188, 1924.

$$dU = \frac{1}{2\mu} \left(S_1^2 + S_2^2 \right) = \frac{1}{2\mu} \left[\left(\frac{\delta \xi}{\delta x} \right)^2 + \left(\frac{\delta \xi}{\delta y} \right)^2 \right]$$

and the total energy is

$$U = \frac{1}{2u} \int \int \left[\left(\frac{\partial \xi}{\partial x} \right)^2 + \left(\frac{\partial \xi}{\partial y} \right)^2 \right] dx dy. \tag{38}$$

This energy is equivalent to the work of the forces producing the couple

or
$$\frac{1}{2}$$
 Q τ , where

$$Q = -\int \int \left(x \frac{\partial \xi}{\partial x} + y \frac{\partial \xi}{\partial y} \right) dxdy$$
$$= 2 \int \int \xi dxdy. \tag{39}$$

The last member results from integration by parts, and knowing $\xi = 0$ on the boundary.

Transforming equation (13) leads to the suggestion that

$$\xi = c(a^4 - k^4) (\beta^4 - k^4), \tag{40}$$

is a possible stress function for the region in the W plane. Here c is a constant to be determined. From (39)

$$Q = 2e \int \int (a^4 - k^4) (\beta^4 - k^4) (a^2 + \beta^2) da d\beta$$

$$= \frac{256}{105} ek^{12}.$$
(41)

Also

$$U = \frac{1}{2\mu} \int \int \left[\left(\frac{\partial \xi}{\partial x} \right)^2 + \left(\frac{\partial \xi}{\partial y} \right)^2 \right] dxdy$$

$$= \frac{1}{2\mu} \int \int \left[\left(\frac{\partial \xi}{\partial a} \right)^2 + \left(\frac{\partial \xi}{\partial \beta} \right)^2 \right] dad\beta$$

$$= \frac{2048}{315} \frac{c^2 k^{16}}{\mu}. \tag{42}$$

From

$$U = \frac{1}{2}Q\tau$$
, $c = \frac{3\mu\tau}{16k^4}$,

and

$$Q = \frac{16}{35} \mu \tau k^8,$$

or

$$Q' = 8/35 \,\mu\tau k^8 = .22857 \mu\tau k^8. \tag{43}$$

When
$$\xi = c \left(\cos \frac{\pi a^2}{2k^2} \cos \frac{\pi \beta^2}{2k^2} \right)$$
, a similar procedure leads to

$$Q' = .224 \mu \tau k^8$$
. (44)

To obtain the approximate shear stress, from (40) is found

$$\begin{split} \mathbf{S}_1 &= -\frac{\partial \xi}{\partial \mathbf{x}} = \mathbf{h}^2 \left[\beta \frac{\partial \Psi}{\partial \beta} - \alpha \frac{\partial \Psi}{\partial \alpha} \right] \\ &= 4 \mathrm{ch}^2 \mathbf{k}^4 [\alpha^4 - \beta^4] \\ &= 3/4 \mu \tau [\alpha^2 + \beta^2]. \end{split}$$

At

$$a^2 = k^2$$
, and $\beta = 0$; or at $\beta^2 = k^2$, and $a = 0$;

$$S_1 = \frac{3}{4} \mu \tau k^2$$

$$= .75 \mu \tau k^2.$$
(45)

Another method yielding improved results, though much more calculation is required, is from the theorem of "Virtual Displacements", which states that for an arbitrary displacement from a state of equilibrium, the variation of the total potential energy H, is zero, that is $\delta H = 0$. Thus when

$$\xi = c_1 \cos \frac{\pi a^2}{2k^2} \cos \frac{\pi^2}{2k^2} + c_2 \cos \frac{3\pi a^2}{2k^2} \cos \frac{3\pi \beta^2}{2k^2}$$

the parameters c_1 and c_2 are determined from

$$\delta \mathbf{H} = \delta(\mathbf{U} - \mathbf{Q}\tau) = 0. \tag{46}$$

¹A. und L. Föppl, Drang und Zwang, Bd. I, p. 58, 1924. Handbuch der Physik, Bd. VI, p. 71, 1928.

10. General Curvilinear Rectangle. For a curvilinear rectangle bounded by arcs of the parabolas $a = a_1$, $a = a_2$, $\beta = \beta_1$, and $\beta = \beta_2$, a solution of $\nabla^2 \Psi = 0$, and satisfying

$$\Psi = \tau/8 (a^2 + \beta^2)^2$$

$$= f_1(\beta) \text{ on } a = a_1 \text{ for } \beta_1 < \beta < \beta_2,$$

$$= f_2(\beta) \text{ on } a = a_2 \text{ for } \beta_1 < \beta < \beta_2,$$

$$= F_1(a) \text{ on } \beta = \beta_1 \text{ for } a < a < a_2$$

$$= F_2(a) \text{ on } \beta = \beta_2 \text{ for } a < a < a_2$$

$$= F_2(a) \text{ on } \beta = \beta_2 \text{ for } a < a < a_2$$

is

$$\Psi = \sum_{n=1}^{\infty} \left[a_{n} \sinh \frac{n\pi(\beta_{2} - \beta)}{(a_{2} - a_{1})} + a_{n}' \sinh \frac{n\pi(\beta - \beta_{1})}{(a_{2} - a_{1})} \right] \\
= \frac{n\pi(a - a_{1})}{\sin \frac{(a_{2} - a_{1})}{n\pi(\beta_{2} - \beta_{1})}} \\
= \frac{\sin \frac{n\pi(a_{2} - a_{1})}{(a_{2} - a_{1})} \\
= \frac{\sum_{n=1}^{\infty} \left[b_{n} \sinh \frac{n\pi(a_{2} - a)}{(\beta_{2} - \beta_{1})} + b_{n}' \sinh \frac{n\pi(a_{2} - a_{1})}{(\beta_{2} - \beta_{1})} \right] \\
= \frac{\sin \frac{n\pi(\beta - \beta_{1})}{(\beta_{2} - \beta_{1})} \\
= \frac{\sin \frac{n\pi(\alpha_{2} - a_{1})}{(\beta_{2} - \beta_{1})}} \\
= \frac{\sin \frac{n\pi(\alpha_{2} - a_{1})}{(\beta_{2} - \beta_{1})} \\
= \frac{\sin \frac{n\pi(\alpha_{2} - a_{1})}{(\beta_{2} - \beta_{1})} \\
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= \frac{\sin \frac{n\pi(\alpha_{2} - a_{1})}{(\beta_{2} - \beta_{1})}} \\
= \frac{\sin \frac{n\pi(\alpha_{2} - a_{1})}{(\beta_{2} - \beta_{1})}} \\
= \frac{\sin \frac{n\pi(\alpha_{2} - a_{1})}{(\beta_{2} - \beta_{1})}} \\
= \frac{\sin \frac{n\pi(\alpha_{2} - a_{1})}{(\beta_{2} - \beta_{1})}} \\$$

where a_n, a_n',b_n, b_n' are coefficients in the sine series,

$$f_{1}(\beta) = \sum_{n=1}^{\infty} b_{n} \sin \frac{n\pi(\beta - \beta_{1})}{(\beta_{2} - \beta_{1})},$$

$$f_{2}(\beta) = \sum_{n=1}^{\infty} b_{n}' \sin \frac{n\pi(\beta - \beta_{1})}{(\beta_{2} - \beta_{1})},$$

$$F_{1}(\alpha) = \sum_{n=1}^{\infty} a_{n} \sin \frac{n\pi(\alpha - \alpha_{1})}{(\alpha_{2} - \alpha_{1})},$$

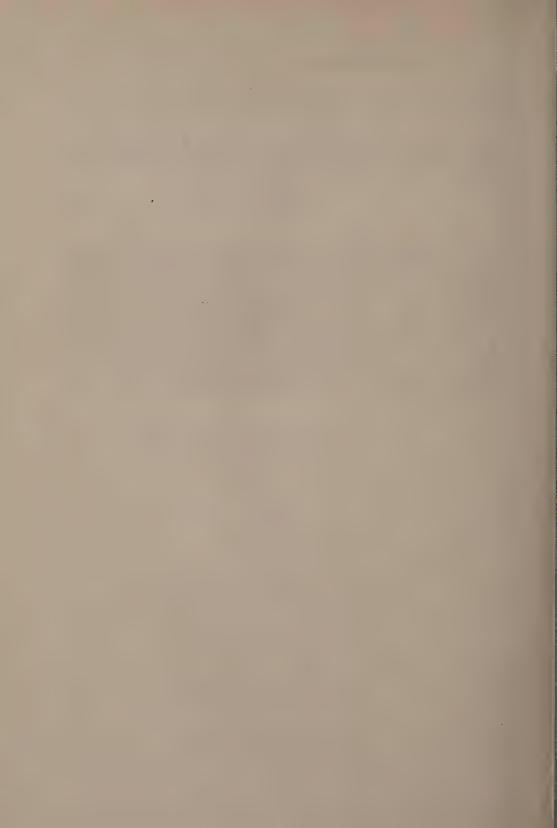
$$(49)$$

$$F_2(a) = \sum_{n=1}^{\infty} a_n' \sin \frac{n\pi(a-a_1)}{(a_2-a_1)}$$
.

Though the above solution is analytically complete, it is quite difficult to effect a numerical calculation. With safety, we may use the approximate method and assume

$$Q = \frac{\mu \tau A^4}{40 \text{ T}} \,. \tag{50}$$

In this paper is given the solution of the torsion problem of a right prism of isotropic material, having a cross section bounded by arcs of orthogonal parabolas. The stress function Ψ satisfying $\nabla^2 \Psi = 0$, and the usual boundary condition is determined by the use of parabolic coordinates, characterized by the conformal transformation of $2Z = W^2$. The solution is given in an infinite series, from which the torque and shears are computed and these are compared with known solutions of related sections given in finite terms. Very satisfactory results are obtained by approximate methods involving only definite integrals and the well known relation between the elastic energy of deformation and the work of the twisting couple. A stress function for the general case of a curvilinear rectangle is given in these coordinates.



THE IMMIGRANT FLORA OF IOWA

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This paper owes its origin to a desire on the part of the author to place on record a comparison of our native flora with that which has come to us as a consequence of the settlement of the state by the white man, and the conversion of our broad expanse of fertile soil into fields of grain crops and pasture, of paved highways, of populous towns and cities, and other evidences of modern civilization. We live in a changing world, and in no respect is the fact more evident than in the plant life which surrounds us. Where a half century ago one might travel for miles over our prairies without seeing a single plant that was not indigenous, today the conditions are almost reversed, and while in our forest and water areas, primeval conditions more nearly continue to exist, still even here a slow but sure change is taking place.

The aboriginal inhabitants appear to have introduced very few plants, and these do not come within the scope of the present list. It is probable that the American Lotus (*Nelumbo lutea* Pers.) was introduced from the Atlantic States by the Indians as a food plant, and our Wild Rice (*Zizania aquatica* L.) owes its presence, in some localities at least, to the same cause.

With the cultivated plants of our fields and gardens, unless escapes, this paper is not concerned, but there are a great many others, many of which are more or less unwelcome, and it is of these that a comprehensive survey may not be unprofitable. While many of these are of a weedy nature, and are ably treated in the Weed Flora of Iowa by Dr. L. H. Pammel and Charlotte M. King, still there are a large number of the less objectionable kind which have escaped from cultivation, or have crept in unbidden, and are likely to become a more or less permanent part of our flora.

From an ecological standpoint our immigrant flora is closely associated with the cultivated plants of our fields, pastures and gardens, only one being hydrophytic in character Water Cress (Radicula nasturtium-aquaticum L.) and a few somewhat xerophytic like the Russian thistle (Salsola

kali tenuifolius Meyer).

Another motive in preparing this paper, is that in future years students may then compare the introduced with the indigenous flora, and be able to show the variation in the proportion of the two classes of plant life as the country becomes older and more densely settled. Undoubtedly the proportion of the former will increase materially as the years go by, while the latter will decrease, partly on account of the slow but sure extermination of many of our rarer species. There are districts in the thickly settled portions of some of our New England States where, at the present time, the introduced plants comprise nearly or quite 50 per cent of the flora. While many years will probably elapse before such a condition exists in Iowa, still as we contemplate the change that has taken place since the settlement

of the state, we can not help realizing that the fuure will modify materially the proportion existing at the present time.

To the early settlers, on their arrival in Iowa, the luxuriant vegetation of prairie and forest was the cause of much rejoicing and satisfaction. It not only indicated an abundantly watered soil of great fertility, but the nutritious grasses for their livestock, the game and wild fruits for their own food, and the timber for fuel and building purposes, were a very present help to those whose store of this world's goods was often meager indeed.

For several years after the virgin soil was broken and planted to cultivated crops, few weeds or other introduced plants gave the settlers much trouble; but wherever the emigrant goes, the seeds of noxious weeds and other undesirable plants follow in his footsteps and soon add materially to the amount of labor necessary to keep his land in the proper condition for the best results.

The seeds of our immigrant flora came to us in various ways. The first arrivals were undoubtedly introduced as impurities in field and garden seeds, by adhering to the clothing or the hair of animals, or were carried in the mud adhering to vehicles and other similar means. Besides these, natural agencies have played a not unimportant part in the introduction of seeds by the action of wind or water, or by animal life. However, these had been at work for generations before the advent of the white man, and had much to do with our so-called indigenous flora.

It is to climatic conditions and to the tide of immigration being from east to west, that we owe the large proportion of our introduced plants having an eastern origin, or having come to us by way of Europe. The number coming from all other directions is only twenty per cent of the whole. Those plants which came to us by way of Europe number 210 species; Asia, 11; Tropical America, 11; Mexico, 1; Eastern States, 3; Southern States, 9; Western States, 18. Of these 245 are herbaceous; 8 are shrubs, and 10 are trees. Regarding their length of life, 121 are annuals, 33 biennials, and 109 perennials.

Our immigrant flora represents 44 of the 277 natural families of flowering plants, and of these 44 families, 7 contain 165 species or 63.8 per cent of the whole. The families Gramineae and Compositae lead with 42 species each, and are followed by the Cruciferae, 27; the Leguminosae, 18; the Solanaceae, 12, and the Caryophyllaceae and Labiatae, 11 each.

It is a noticeable fact that of the two great and closely related families, the grasses and sedges, each having approximately an equal number of species, we do not have within our limits a single introduced plant from the latter group.

The accompanying table gives the number of native and introduced plants with the percentage of the latter in the following publications:

		Native	Introduced	Per cent
Gray's Manual 7 Ed.	(1908)	3413	666	16.3
Arthur, Fl. Iowa	(1876)	867	92	9.5
Upham, Fl. Minn.	(1883)	1 512	148	8.9
Swezey, Fl. Wisc.	(1883)	1337	136	9.2
Aughey, Fl. Nebr.	(1875)	1648	70	4.
Beal and Wheeler, Fl. Mich.	(1892)	1604	142	8.1
Flora of Willoughby, Vt.	(1904)	611	104	14.5
Cratty, Fl. Emmet Co., Iowa	(1904)	537	53	8.9

There are in the herbarium of the Iowa State College, 1,484 native and introduced species and varieties of the Iowa flora, the latter forming 17.7 per cent of the whole.

In the accompanying list of our immigrant flora, the common name, the native habitat, the period of life, whether annual, biennial, or perennial, and the character of growth when not herbaceous are given. Also, there are included in parentheses the locality, date and collector of the oldest Iowa specimen in our herbarium.

Only such plants are included as have been seen by the author and while there are undoubtedly some omissions and also a few which time may prove to be merely waifs, still, on the whole, the list is nearly complete and represents fairly well the conditions at present existing.

SYSTEMATIC LIST

GRAMINEAE

- 1. Digitaria humifusa Pers. Smooth Crab Grass. Annual, common in cultivated ground and waste places; especially troublesome in lawns, late in the season. Naturalized from Europe. (Story Co., 1871, Beardslee.)
- 2. D. sanguinalis (L.) Scop. Crab Grass. Annual, a common weed; coarser than the preceding and more troublesome in gardens. Naturalized from Europe. (Story Co., 1871, Bessey.)
- 3. Panicum miliaceum L. Broomcorn Millet. European Millet. Annual, occasional as an escape. Adventive from Europe. (Ida Co., 1895, Crowley.)
- 4. Echinochloa crusgalli (L.) Beauv. Barnyard Grass. Annual, common in rich cultivated ground and waste places. Variable. Naturalized from Europe. (Story Co., 1875, Bessey.)
- 5. Setaria glauca (L.) Beauv. Yellow Foxtail or Pigeon Grass. This and the two following are our commonest introduced grasses in cultivated fields. Naturalized from Europe. (Story Co., 1883, Bessey.)
- 6. S. verticillata (L.) Beauv. Bristly Foxtail. Annual. Its mature spikes adhere to the clothing or to the hair of animals and it is being rapidly scattered over the state. Naturalized from Europe. (Scott Co., 1866, Parry.)
- 7. S. viridis (L.) Beauv. Green Foxtail. Annual, common, and our most prolific seeded grass. Naturalized from Europe. (Story Co., 1870.)
- 8. S. italica L. Millet. Annual, frequent as an escape, but has not become naturalized. Introduced from Europe. (Story Co., 1880, Fisher.).

- 9 S. italica germanica (Willd.) Richter. German Millet. Annual, infrequent. Introduced from Europe. (Story Co., 1889, Hitchcock.)
- 10. Phleum pratense L. Timothy. Perennial, common in cultivation and extensively naturalized in the temperate zones of both hemispheres. Introduced from Europe (Story Co., 1882, Hitchcock.)
- 11. Sporobolus asperifolius (Nees & Meyer) Thurber. Drop-seed Grass. Perennial. Rare as an introduction on the Northwestern right-of-way. Native on the western plains. (Story Co., 1923, Pammel.)
- 12. Agrostis alba L. (Including A. vulgaris With.) Red-top. Perennial. Common in cultivation and extensively naturalized. Introduced from Europe. (Emmet Co., 1887, Cratty.)
- 13. Holcus lanatus L. Velvet Grass. Perennial; naturalized from Europe but only occasionally found within our limits. (Story Co., 1893, Carver.)
- 14. Avena fatua L. Wild Oat. Annual, a frequent weed in grain fields. Adventive from Europe. (Story Co., 1914, Pammel.)
- 15. A. sativa L. Oat. Annual; adventive along roadsides and in waste places. Introduced from Europe. (Delaware Co., 1880, Hoyt.)
- 16. Cynodon dactylon L. Bermuda Grass. Perennial; rare and not hardy with us. Naturalized from Europe. (Story Co., 1923, Cratty.)
- 17. Eleusine indica Gaertn. Goose Grass, Yard Grass. Annual, a coarse species from southern Asia. Infrequent. (Story Co., 1890, Pammel.)
- 18. Eragrostis cilianensis (All.) Link. (E. megastachya Link.) Stink Grass, Snake Grass. Annual. A worthless, ill smelling species, common in cultiated ground. Naturalized from Europe. (Story Co., 1871, Beardslee.)
- 19. E. minor Host. Annual, similar to the preceding, but smaller in all its parts, and rather rare. Adventive from Europe. (Polk Co., 1927, Fisk.)
- 20. Distichlis spicata (L.) Greene. Spike Grass, Alkali Grass. Perennial; probably introduced in Iowa. Native in saline soil along the Atlantic coast, and rarely in the interior. (Ida Co., 1922, Crawford.)
- 21. Dactylis glomerata L. Orchard Grass. Perennial, a coarse species, frequent in grass land, and in waste places. Naturalized from Europe. (Story Co., 1871, Beardslee.)
- 22. Poa annua L. Low Spear Grass. Annual; common in cultivated and waste land. Introduced from Europe. (Henry Co., 1894, Mills.)

- 23. P. compressa L. Canada Blue Grass. Perennial. Common in cultivation and naturalized from Europe. (Story Co., 1880, Bessey.)
- 24. P. trivialis L. Rough-stalked Meadow Grass. Perennial. Frequent. Naturalized from Europe. (Story Co., 1897, Combs & Pammel.)
- P. pratensis L. Kentucky Blue Grass. Perennial. Commonly naturalized with us, but native further north and west. (Story Co., 1871, Beardslee.)
- Festuca rubra L. Red Fescue. Perennial. An undesirable species quite frequent in lawns. Naturalized from Europe. (Tama Co., 1896, Sirrine.)
- 27. F. ovina L. Sheep Fescue. Perennial; rare, introduced from Europe. (Emmet Co., 1922, Wolden.)
- 28. F. elatior L. Tall or Meadow Fescue. Perennial. Frequent in meadows and waste places. Naturalized from Europe. (Story Co., 1875, Bessey.)
- 29. Bromus secalinus L. Cheat or Chess. Annual. A noxious weed in grain fields and waste places. Adventive from Europe. (Story Co., 1871, Beardslee.)
- 30. B. breviaristatus (Hook.) Buckley (B. marginatus Nees.) Short-lived perennial. Cultivated from the west, and rare as an escape. (Story Co., 1890, Pammel.)
- 31. B. racemosus L. (B. commutatus Schrad.) Annual, rare. Adventive from Europe; a variable species. (Story Co., 1895, Carver.)
- 32. B. hordeaceus L. Annual, rare. Adventive from Europe. (Webster Co., 1916, Paige.)
- 33. B. hordeaceus glabrescens (Coss.) Spear. Annual; rare. Adventive from Europe. (Pottawattamie Co., 1895, Pammel.)
- 34. B. japonicus Thunb. Annual. This includes B. arvensis of our Manuals, a species which does not occur in America. Frequent in waste places. Introduced from Europe. (Story Co., 1894, Carver.)
- 35. B. inermis Leyss. Smooth Brome. Perennial; common in cultivation and extensively escaped. Naturalized from Europe. (Story Co., 1894.)
- 36. B. tectorum L. Annual. A worthless, weedy species extensively naturalized from Europe. (Story Co., 1894, Weaver.)
- 37. Lolium perenne L. Rye Grass. Perennial; a frequent escape from cultivation; a native of Europe. (Story Co., 1888, Crozier.)

- 38. L. multiflorum L. Italian Rye Grass. Biennial or perennial. An escape in waste places. Introduced from Europe. (Story Co., 1889, Hitchcock.)
- 39. L. temulentum L. Darnel. Annual. A frequent weed in grain fields and waste places. Adventive from Europe. (Story Co., 1875, Bessey.)
- Agropyron repens (L.) Beauv. Quack Grass. Perennial; one of our worst weeds. Naturalized from Europe. (Story Co., 1871, Beardslee.)
- 41. Secale cereale L. Rye. Annual or biennial. An occasional escape. Introduced from Europe. (Story Co., 1892, Stewart.)
- 42. Hordeum jubatum L. Squirrel Tail Grass. Wild Barley. Annual or biennial. A miserable weed, introduced from Europe. (Story Co., 1871, Beardslee.)

COMMELINACEAE

43. Commelina communis L. Day Flower. Perennial. Rare as a weed around dooryards and gardens. Introduced from Asia. (Van Buren Co., 1925, Pammel.)

LILACEAE

44. Asparagus officinalis L. Garden Asparagus. Perennial. Frequent along roadsides, the seed scattered by birds. Introduced from Europe. (Story Co., 1892, Stewart.)

IRIDACEAE

45. Belamcanda chinensis (L.) DC. Blackberry Lily. Perennial. Rare along roadsides and in waste places. Introduced from Europe. (Dubuque Co., 1922, Pammel.)

SALICACEAE

- 46. Populus alba L. White poplar. Medium sized tree. Frequent as an escape. Introduced from Europe. (Story Co., 1897, Combs.)
- 47. P. candicans L. Balm of Gilead. Medium sized tree. An occasional escape. Introduced from Europe.
- 48. Salix alba-vitellina (L.) Koch. White Willow. Shrub or small tree. Our most common species in cultivation, and a frequent escape. Introduced from Europe. (Story Co., 1892, Sirrine.)

MORACEAE

- 49. Cannabis sativa L. Hemp. Annual. A common escape. The seed is mixed with millet and mustard seed in the birdseed of commerce. Introduced from southern Asia. (Fayette Co., 1894, Fink.)
- 50. Maclura pomifera Raf. Osage Orange. Shrub or small tree. An escape in the southern part of the state. Native from Missouri to Texas. (Decatur Co., 1892, Anderson.)
- 51. Morus alba L. Mulberry. Medium sized tree. Frequent as an escape. Naturalized from Europe. (Pottawattamie Co., 1914.)

URTICACEAE

52. Urtica urens L. Nettle. Perennial. Sparingly introduced in the eastern part of the state. Adventive from Europe. (Johnson Co., 1894, Fitzpatrick.)

POLYGONACEAE

- Rumex patientia L. Patience Dock. Perennial. An escape in German settlements. Introduced from Europe. (Winneshiek Co., 1895, Goddard.)
- 54. R. crispus L. Curly Dock. Perennial. A common and troublesome weed. Naturalized from Europe. (Winneshiek Co., 1879, Holway.)
- 55. R. obtusifolius L. Bitter Dock. Perennial. Frequent in the north-eastern counties. Introduced from Europe. (Winneshiek Co., 1888, Holway.)
- 56. R. acetosella L. Sheep Sorrel. Perennial. A common unlawful weed in lawns and pastures. Naturalized from Europe. (Winneshiek Co., 1888, Holway.)
- 57. Polygonum orientale L. Prince's Feather. Annual. A tall species escaped from cultivation. Introduced from Asia. (Story Co., 1902, Pammel.)
- 58. P. persicaria L. Lady's Thumb. Annual. Common in waste places. Naturalized from Europe. (Story Co., 1888, Beyer.)
- P. convolvulus L. Black Bindweed. Annual. A common troublesome weed in cultivated ground. Naturalized from Europe. (Chickasaw Co., 1890, Rolfs.)
- 60. Fagopyrum esculentum Moench. Buckwheat. Annual. Persists as a weed for some time after cultivation. Introduced from Europe. (Boone Co., 1898, Pammel.)

CHENOPODIACEAE

- 61. Kochia scoparia (L.) Schrad. Kochia. Annual. The typical plant rare. Adventive from Europe. (Story Co., 1927, Cratty.)
- 62. K. scoparia trichophila Bailey. Burning Bush, Summer Cypress. Annual. A frequent escape. The whole plant turns purple-red in autumn. Introduced from Europe. (Hardin Co., 1912, Pammel.)
- 63. Chenopodium ambrosioides L. Mexican Tea. Annual, infrequent. A strong scented plant introduced from tropical America. (Story Co., 1905, Carver.)
- 64. C. ambrosioides anthelminticum (L.) Gray. Wormseed. Annual with us, and a form of the preceding. Introduced from tropical America. (Story Co., 1905; Carver.)
- 65. C. botrys L. Jerusalem Oak. Annual. Infrequent. Adventive from Europe. (Fayette Co., 1894, Fink.)
- 66. C. glaucum L. Oak-leaved Goosefoot. Annual. Rare in waste places. Adventive from Europe. (Fayette Co., 1911, Anderson.)
- 67. C. album L. (Including C. pagamum Reich.) Lamb's Quarters. Pigweed. Annual. A variable weed, everywhere common. Naturalized from Europe. (Story Co., 1888, Beyer.)
- 69. C. urbicum L. City Goosefoot. Annual. Infrequent. Adventive from Europe. (Polk Co., 1894, Pammel.)
- 69. Atriplex argentea Nutt. Salt Bush. Annual. Rare. Introduced from the western plains. (Polk Co., 1911, Iowa Seed Co.)
- 70. A. patula L. Orach. Common and variable. Probably not native with us, but native along the Atlantic coast and in Europe. (Winneshiek Co., 1895, Goddard.)
- A. patula hastata (L.) Gray. Orach. Annual, the wide hastateleaved form. With the preceding. Introduced from Europe. (Taylor Co., 1897, Menoher.)
- 72. Salsola kali tenuifolius G. F. W. Meyer. (S. pestifer A. Nelson.)
 Russian Thistle. Annual. A common spiny-leaved weed in dry
 ground. Naturalized from Europe. (Emmet Co., 1887, Cratty.)

AMARANTHACEAE

73. Amaranthus retroflexus L. Red Root, Pigweed. Annual. Common in rich, cultivated ground. Naturalized from tropical America. (Story Co., 1888, Beyer.)

- 74. A. hybridus L. Green Amaranth. Annual. Infrequent. Adventive from tropical America. (Webster Co., 1916, Paige.)
- 75. A. blitoides S. Watson. Prostrate Pigweed. Annual. Common. Naturalized from west of the Rocky Mountains. (Emmet Co., 1882, Cratty.)
- 75a. Axyris amarantoides L. Russian Pigweed. Annual. A weed introduced from the grain fields of the Dakotas and Canada. A native of Russia and Siberia. (Crawford Co., 1929, Pammel and Butler.)
- A. torreyi (A. Gray) Benth. Torrey's Amaranth. Annual. Infrequent. Probably introduced. Native on the western plains. Resembles an Acnida. (Marshall Co., 1891, Stewart.)

AIZOACEAE

77. Mollugo verticillata L. Carpet Weed. Annual. Frequent in sandy soil. Naturalized from further south. (Winneshiek Co., 1881, Holway.)

CARYOPHYLLACEAE

- 78. Stellaria graminea L. Starwort. Perennial. Rare. Introduced from Europe. (Emmet Co., 1923, Wolden.)
- 79. S. media (L.) Cyrill. Common Chickweed. Annual or perennial. Common, and a troublesome weed in dooryards. Naturalized from Europe. (Winneshiek Co., 1881, Holway.)
- 80. Cerastium vulgatum L. Mouse-ear Chickweed. Perennial. A common weed in pastures and waste places. Naturalized from Europe. (Hamilton Co., 1892, Stewart.)
- 81. Agrostemma githago L. Corn Cockle. Annual. A common weed in wheat fields and waste places. Introduced from Europe. (Winneshiek Co., 1895, Goddard.)
- 82. Lynchis alba L. White campion. Perennial. Frequent among shrubbery and in waste places. Naturalized from Europe. (Winneshiek Co., 1876, Holway.)
- 83. Silene dichotoma Ehrh. Catchfly. Annual. Common, especially in clover fields. Introduced from Europe. (Mills Co., 1907, Plumb.)
- 84. S. noctiflora L. Night-flowering Catchfly. Annual. A frequent weed around homesteads. Adventive from Europe. (Story Co., 1890, Sirrine.)
- 85. S. cserei Baumg, Campion, Annual, Rare. Adventive from Europe. (Chickasaw Co., 1926, Spiker.)

- 86. L. latifolia (Mill.) Britten & Rendle. Bladder Campion. Perennial. Frequent. Naturalized from Europe. (Story Co., 1897, Combs.)
- 87. Saponaria officinalis L. Bouncing Bet. Perennial. Frequent escape to roadsides and vacant spaces. Naturalized from Europe. (Fayette Co., 1894, Fink.)
- 88. S. vaccaria L. Cow-herb. Annual. Common in grain fields. Adventive from Europe. (Winneshiek Co., 1895, Goddard.)

PORTULACACEAE

89. Portulaca oleracea L. Purslane. Annual. Everywhere common in cultivated ground. Naturalized from Europe. (Story Co., 1888, Hitchcock.)

RANUNCULACEAE

- 90. Ranunculus acris L. Meadow Buttercup. Perennial. Frequent. Naturalized from Europe. (Allamakee Co., 1904, Pammel.)
- 91. Delphinium ajacis L. Rocket Larkspur. Annual. Rare as an escape to roadsides. Introduced from Europe. (Fayette Co., 1896, Fink.)
- 91a. Berberis thunbergii DC. Japanese Barberry. A small shrub from Japan, common in cultivation, but rare as an escape. (Floyd Co., 1929, Pammel.)
- 92. D. cultorum Voss. Candle Larkspur. Perennial. Frequently escaped from gardens. Old World form, whose origin has not been worked out. (Boone Co., 1924, Pammel.)

BERBERIDACEAE

93. Berberis vulgaris L. Common Barberry. Shrub. Frequent as an escape. No longer sold by nurserymen on account of its being the alternate host of Puccinia graminis, the black rust of wheat. Naturalized from Europe. (Story Co., 1892, Stewart.)

PAPAVERACEAE

- 94. Chelidonium majus L. Celandine. Biennial. Rare as an escape. Introduced from Europe. (Cherokee Co., 1928, Pammel.)
- 95. Argemone mexicana L. Prickly Poppy. Annual. An occasional escape from gardens. Introduced from Mexico. (Henry Co., 1897, Mills.)

CRUCIFERAE

96. Draba verna L. Whitlaw Grass. Annual. Rare. Adventive from Europe. (Story Co., 1897, Combs.)

- 97. Berteroa incana (L.) DC. Hoary Alyssum. Annual or biennial. Frequent in cultivated land. Naturalized from Europe. (Mills Co., 1919.)
- 98. Thlaspi arvense L. Penny Cress. Annual. Common. Naturalized from Europe. (Marion Co., 1907, Pammel.)
- 99. Lepidium apetalum Willd. (L. densiflorum Schrad.) Peppergrass.
 Annual. Very common in grain fields. Naturalized from Europe.
 (Chickasaw Co., 1890, Rolfs.)
- 100. L. campestre L. Downy Peppergrass. Annual. Becoming frequent. Introduced from Europe. (Buchanan Co., 1925, Walters.)
- L. perfoliatum L. Perfoliate-leaved Peppergrass. Annual or biennial. Rare. Adventive from Europe. (Story Co., 1920, Hayden.)
- 102. L. draba L. Perennial Peppergrass. A harmful weed, naturalized from Europe, and becoming frequent. (Carroll Co., 1920, Cowles.)
- 103. Capsella bursa-pastoris (L.) Medic. Shepherd's Purse. Annual or winter annual. Very common. Naturalized from Europe. (Winneshiek Co., 1893, Holway.)
- 104. Camelina sativa (L.) Crantz. False Flax. Annual. A frequent weed in flax fields and waste places. Introduced from Europe. (Winnesiek Co., 1893, Holway.)
- 105. C. microcarpa Andrz. Smaller False Flax. Annual. Rare. Adventive from Europe. (Dickinson Co., 1893, Conard.)
- 106. Raphanus raphanistrum L. Wild Radish, Jointed Charlock. Annual or biennial. Infrequent. Naturalized from Europe. (Winneshiek Co., 1895, Goddard.
- Brassica arvensis (L.) Kuntze. Charlock. Annual. A very common, noxious weed. Naturalized from Europe. (Clayton Co., 1891, Pammel.)
- 108. B. alba (L.) Boiss. White Mustard. Annual. Rare as an escape. Introduced from Europe. (Story Co., 1894, Pammel.)
- 109. B. juncea (L.) Cosson. Indian Mustard. Annual. Common and often confused with B. arvensis. Naturalized from Europe. (Kossuth Co., 1897, Pammel.)
- 110. B. nigra (L.) Koch. Black Mustard. Annual. A common weed, mostly in waste places. Naturalized from Europe. (Story Co., 1891, Rolfs.)
 B. napus L. Rape, and B. rapa L. the turnip, both biennials, introduced from Europe, tend to escape and occasionally persist for a few

years.

- 111. Eruca sativa Mill. Garden Rocket. Annual. Rare as a garden escape. Introduced from Europe. (Plymouth Co., 1912, Millner.)
- 112. Diplotaxis muralis (L.) DC. Wall Mustard. Annual or biennial. Sparingly adventive from Europe. (Emmet Co., 1925, Wolden.)
- 113. Conringia orientalis (L.) Dumort. Hare's Ear Mustard. Annual. Sparingly naturalized from Europe. (Decatur Co., 1911, Anderson.)
- 114. Sisymbrium officinale leiocarpum DC. Hedge Mustard. Annual or biennial. A common weed, naturalized from Europe. The species with pubescent pods has not been detected with us. (Winneshiek Co., 1881, Holway.
- 115. S. altissium L. (Norta, Britton). Tumble Mustard. Annual or biennial. Common in waste places, especially around grain elevators. Naturalized from Europe. (Story Co., 1890, Sirrine.)
- 116. S. sophia L. Hoary Hedge Mustard. Annual or winter annual. Rare. Adventive from Europe. (1919, Melhus.)
- 117. S. thalianum (L.) J. Gay. Mouse-ear Cress. Annual. Rare with us; reported only from Fort Dodge. Adventive from Europe. (Webster Co., 1916, Paige.)
- 118. Hesperis matronalis L. Dame's Violet. Biennial or perennial. Occasionally escaped to roadsides. (Introduced from Europe. (Webster Co., 1916, Paige.)
- 119. Radicula nasturtium-aquaticum (L.) Britten & Rendle. Water Cress. Perennial. Rare along brooks and ditches. Introduced from Europe. (Fayette Co., 1893, Anderson.)
- 120. R. sylvestris (L.) Druce. Perennial; rare. Adventive from Europe. (Story Co., 1926, Cratty.)
- 121. R. armoracia (L.) Robinson. Horse Radish. Perennial. Frequently escaped. Introduced from Europe. (Winneshiek Co., 1895, Goddard.)
- 122. Barbarea vulgaris R. Br. Winter Cress, Yellow Rocket. Perennial; frequent. Introduced from Europe, but native far northward. (Story Co., 1900, Sirrine.)

CRASSULACEAE

123. Sedum purpureum Tausch. (S. telephium of Manual 6th ed.) Live-Forever. Perennial. Commonly cultivated and an occasional escape. Introduced from Europe. (Decatur Co., 1897, Anderson.)

SAXIFRAGACEAE

124. Ribes odoratum Wend. (Not R. aureum Pursh.) Flowering Currant. Yow shrub. Frequently escaped, and common in cultivation. Perhaps native in our southwestern counties. Native from Nebraska to Texas. (Henry Co., 1897, Pammel.)

ROSACEAE

- 125. Pyrus malus L. The common apple. Tree. Introduced from Europe, and sometimes escaped. (Jones Co., 1920, Pammel.)
- 126. P. baccata L. Siberian Crab Apple. Small tree. Rare as an escape. Cultivated from northern Asia. (Emmet Co., 1922, Wolden.)
- 127. Potentilla recta L. Five-Finger. Perennial. Rare. Reported only from one locality. Adventive from Europe. (Story Co., 1922, Pammel.)
- 127a. Prunus cerasus L. Sour Cherry. A species from Europe, very common in cultivation, and occasionally escaped. Floyd Co., 1929, Pammel.)
- 127b. Sorbus aucuparia L. The European Mountain Ash, or Rowan Tree. A small tree, common in cultivation, but rare as an escape. (Howard Co., 1927, Mrs. F. May Tuttle.)
- 128. Rosa rubiginosa L. Sweet briar. Low shrub. Frequently escaped. Introduced from Europe. (Des Moines Co., 1925, Pammel.)
- 129. Prunus persica (L.) Stokes. Peach. Small tree. Escaped from cultivation in the southeastern counties. Native of China, but once thought to have come from Persia, whence the specific name. (Van Buren Co., 1923, Pammel.)

LEGUMINOSEAE

- 130. Trifolium arvense L. Rabbit-foot or Stone Clover. Annual. Frequent in rather dry ground. Introduced from Europe. (Winneshiek Co., 1895, Fitzpatrick.)
- 131. T. incarnatum L. Crimson Clover. Annual. Rare as an escape. Introduced from Europe. (Iowa Co., 1902, Welch.)
- 132. T. pratense L. Common Red Clover. Perennial. Escaped to roadsides. Introduced from Europe. (Story Co., 1880, Bessey.)
- 133. T. repens L. White Clover. Perennial. Common. Introduced from Europe. Doubtfully indigenous to America. (Story Co., 1892, Carver.)
- 134. T. hybridum L. Alsike Clover. Perennial. A common escape. Introduced from Europe. (Emmet Co., 1885, Cratty.)

- 135. T. agrarium L. Yellow Hop Clover. Annual. A rare escape. Introduced from Europe. (Buchanan Co., 1920, Pammel.)
- 136. T. procumbens L. Low Hop Clover. Annual. Frequent. Naturalized from Europe. (Story Co., 1880, Bessey.)
- 137. Melilotus officinalis (L.) Lam. Yellow Swe etClover. Biennial. Common in waste places. Naturalized from Europe. (Story Co., 1895, Carver.)
- 138. M. alba Desr. White Sweet Clover. Annual or biennial. Cultivated and a common escape. Naturalized from Europe. (Winneshiek Co., 1881, Holway.)
- 139. Medicago sativa L. Alfalfa. Perennial. Common in cultivation and as an escape. Naturalized from Europe. (Story Co., 1882, Bessey.)
- 140. M. falcata L. Yellow-flowered Alfalfa. Perennial. Rare. Adventive from Europe. (Story Co., 1928, Cratty.)
- 141. M. lupulina L. Black Medick. Perennial. Frequent. Adventive from Europe. (Story Co., 1898, Hodson.)
- 142. Anthyllis vulneraria L. Kidney Vetch. Perennial. Rare. Adventive from Europe. (Wright Co., 1925, Hayden.)
- 143. Robinia pseudo-acacia L. Common Locust. Small tree. Sparingly naturalized. Native further south. (Louisa Co., 1895, Carver.)
- 144. R. hispida L. Bristly Locust. Rose Acacia. Small tree. An occasional escape from cultivation. Native from Virginia to Georgia. (Chickasaw Co., 1926, Spiker.)
- 145. Coronilla varia L. Coronilla Axwort. Perennial. Rare. Adventive from Europe. (Plymouth Co., 1924, Hahn.)
- 146. Vicia sativa L. Spring Vetch. Annual. An infrequent escape. Introduced from Europe. (Chickasaw Co., 1926, Spiker.)
- 147. V. villosa Roth. Hairy or Winter Vetch. Annual or biennial. A frequent escape from cultivation. Introduced from Europe. (Story Co., 1890, Sirrine.)
- 147a. Geranium pusillum. Crane's Bill. A slender annual introduced in grass seed. Native of Europe. (Poweshiek Co., 1919, Conard.)

LINACEAE

148. Linum usitatissimum L. Common Flax. Annual. An occasional escape. Does not persist long. Introduced from Europe. (Winneshiek Co., 1895, Goddard.)

GERANIACEAE

149. Erodium cicutarium (L.) L'Her. Storksbill, Alfiaria. Annual. A rare, hairy plant, adventive from Europe. (Story Co., 1914, Pammel.)

ZYGOPHYLLACEAE

150. Tribulus terrestris L. Caltrop. Puncture Vine. Annual. Adventive from Europe. (Ringgold Co., 1925, Swigart.)

EUPHORBIACEAE

- Euphorbia essula L. Spurge. Perennial. A deep rooted species becoming frequent. Naturalized from Europe. (Story Co., 1907, Pammel.)
- 152. E. cyparissias L. Cypress. Spurge. Grave Moss. Perenial. A common escape. Introduced from Europe. (Floyd Co., 1875, Arthur)
- 153. E. peplus L. Petty Spurge. Annual. Rare. Adventive from Europe. (Muscatine Co., 1891, Reppert.)

RHAMNACEAE

154. Rhamnus cathartica L. Common Buckthorn. Shrub. An occasional escape. Introduced from Europe. (Floyd Co., 1918, Pammel.)

MALVACEAE

- 155. Abutilon thophrasti Medic. Butter Print, Velvet Leaf. Annual. Common. Naturalized from Europe. (Winneshiek Co., 1879, Holway.)
- 156. Sida spinosa L. Indian or False Mallow. Annual. Infrequent, naturalized from the tropics. (Madison Co., 1892, Carver.)
- 157. Althaea rosea Cov. Hollyhock. Biennial. Frequent as an escape from cultivation. Introduced from China. (Floyd Co., 1924, Pammel.)
- 158. Malva rotundifolia L. Common Mallow. Annual or biennial. A common weed in yards. Naturalized from Europe. (Chickasaw Co., 1890, Rolfs.)
- 159. M. verticillata L. (Including M. crispa L.) Curled Mallow. Tall annual, rare. Adventive from Europe. (Winneshiek Co., 1895, Goddard.)
- 160. M. sylvestris L. High Mallow. Biennial. Infrequent. Introduced from Europe. (Johnson Co., 1893, Fitzpatrick.)

161. Hibiscus trionum L. Flower-of-an-hour, Shoo-Fly. Annual. A troublesome weed in some places. Naturalized from Europe. (Story Co., 1882, Wood.)

GUTTIFERACEAE

162. Hypericum perforatum L. Common St. John's-wort. Perennial; infrequent. Introduced from Europe. (Winneshiek Co., 1918, Cratty.)

ELAEAGNACEAE

163. Eleaeaguus angustifolia L. Russian Olive, Oleaster. Shrub or small tree. Rare as an escape from cultivation. Introduced from Asia. (Dickinson Co., 1926, Pammel.)

ONAGRACEAE

- 164. *Enothera laciniata* Hill. (O. sinuata L.) Evening Primrose. Winter annual. Rare; introduced from the western plains. (Polk Co., 1924, Zuck.)
- 165. *Œ. nuttallii* Sweet. (*Aongra* Spach.) Primrose. Perennial. Very rare; probably introduced from the west. (Story Co., 1920, King.)

UMBELLIFEREAE

- 166. Conium maculatum L. Poison Hemlock. Biennial. Sometimes cultivated under the false name of California Fern. Infrequent. Naturalized from Europe. A decoction of the bulbous roots was used to kill criminals by the ancient Greeks. (Boone Co., 1926.)
- 166a. Torilis authriscus (L.) Gmel. Knotted Hedge Parsley. Annual; introduced from Europe. Rare. (Hardin Co., 1929, Pammel.)
- 167. Carum carvi L. Caraway. Biennial. Infrequent. Introduced from Europe. (Fayette Co., 1885.)
- 168. Foeniculum vulgare Hill. Fennel. Perennial. Rare. Adventive from Europe. (Story Co., 1924, Pammel.)
- 169. Pastinaca sativa L. Parsnip. Biennial. A common escape along roadsides. Naturalized from Europe. (Dubuque Co., 1895, Fitzpatrick.)
- 170. Daucus carota L. Carrot. Biennial. An undesirable weed in many places. Naturalized from Europe. (Adair Co., 1891, Stewart.)

PRIMULACEAE

171. Lysimachia nummularia L. Moneywort, Creeping Jenny. Perennial. A frequent escape. Naturalized from Europe. (Story Co., 1892, Carver.)

ASCLEPIADACEAE

172. Vincetoxicum carolinense (Jacq.) Britton. Angle-pod. Perennial. A rare introduction in gardens, and native further south. (Fremont Co., 1925, Pammel.)

CONVOLVULACEAE

- 173. Ipomoea hederacea Jacq. Ivy-leaved Morning-glory. Annual. A frequent escape from cultivation. Introduced from tropical America. (Boone Co., 1912, Pammel.)
- 174. I. purpurea (L.) Roth. Common Morning-glory. Annual. Frequently escaped. Introduced from tropical America. (Lee Co., 1891, Rolfs.)
- 175. Convolvulus japonicus Thunb. California Rose is a misnomer. Perennial. A completely sterile form, rarely escapes from cultivation by suckering. Introduced from Japan. (Clayton Co., 1928, Miss Helwig.)
- 176. C. arvensis L. European Morning-Glory, Field Bindweed. Perennial. A troublesome weed. Naturalized from Europe. (Fayette Co., 1893, Fink.)
- 177. Cuscuta epithamum L. Dodder. Annual. A frequent parasite on clover. Introduced from Europe. (Story Co., 1904, Pammel.)

POLEMONIACEAE

- 178. Phlox paniculata L. Garden Phlox. Perennial. An occasional escape from gardens. Native further east and south. (Jackson Co., 1919, Pammel.)
- 179. *P. subulata* L. Ground or Moss Pink. Perennial. Native of the Atlantic States. Cultivated and persistent around old gardens. (Fayette Co., 1893, Fink.)
- 180. Gilia intertexta Benth. (Navarretia Hook.) Annual. A small Pacific coast species recently introduced here; known from but two localities. (Page Co., 1920, Eichling.)

BORAGINACEAE

- 181. Cynoglossum officinale L. Common Hound's Tongue. Biennial. Frequent. Naturalized from Europe. (Madison Co., 1895, Carver.)
- 182. Lappula echinata Gilibert. (Echinospermum lappula Lehm. Stickseed. Annual. Common. Naturalized from Europe. (Winneshiek Co., 1881, Holway.)
- 183. Echium vulgare L. Blue Weed, Blue Devil. Biennial. Infrequent. Naturalized from Europe. (Cherokee Co., 1924, Pammel.)

VERBENACEAE

184. Verbena hybrida Voss. Common Garden Verbena. Perennial. A hybrid derived from South American species, and an occasional escape. (Boone Co., 1924, Pammel.)

LABIATE

- 185. Marubium vulgare L. Common Horehound. Perennial. Frequent. Naturalized from Europe. (Fremont Co., 1914, Pammel.)
- 186. Nepeta cataria L. Catnip. Perennial. Very common. Naturalized from Europe. (Emmet Co., 1884, Cratty.)
- 187. N. hederacea (L.) Trevison. (Glechona L.) Ground Ivy, Gill-over-the-ground. Frequent; a creeping perennial. Naturalized from Europe. (Winneshiek Co., 1881, Holway.)
- 188. Galeopsis tetrahit L. Hemp Nettle. Annual. A coarse plant, quite rare. Naturalized from Europe. (Winneshiek Co., 1895, Goddard.)
- 189. Lamium amplexicaule L. Henbit. Perennial. Infrequent. Adventive from Europe. (Taylor Co., 1914, Mason.)
- 190. Leonurus cardiaca L. Motherwort. Perennial. A coarse plant, frequent. Naturalized from Europe. (Johnson Co., 1887, Hitchcock.)
- 191. L. sibiricus L. Siberian Motherwort. Biennial. Rare. Adventive from Europe. (Poweshiek Co., 1923, Conard.)
- 192. Salvia sylvestris L. Sage. Perennial. Very rare. Adventive from Europe. (Dickinson Co., 1920, Cratty.)
- 193. Mentha spicata L. Spearmint. Perennial. Infrequent. Naturalized from Europe. (Decatur Co., 1896, Anderson.)
- 194. M. piperita L. Peppermint. Perennial. Infrequent. Naturalized from Europe. (Decatur Co., 1903, Anderson.)
- 195. M. gentilis L. Creeping or Downy Mint. Perennial. Rare. Naturalized from Europe. (Clinton Co., 1896, Pammel.)

SOLANACEAE

- 196. Solanum dulcamara L. Bittersweet. Perenial. A hardy vine and a frequent escape. Naturalized from Europe. (Kossuth Co., 1897. Burdell.)
- 197. S. triflorum Nutt. Annual. Infrequent. Native west and southwest. (Fayette Co., 1894, Fink.)

- 198. S. carolinense L. Horse Nettle. Perennial. A frequent unlawful weed. Naturalized from the south. (Story Co., 1890, Stewart.)
- 199. S. sisymbriifolium Lam. Viscid Nightshade. Annual. Rare. Adventive from tropical America. (Jefferson Co., 1920, Deal.)
- 200. S. rostratum Dunal. Buffalo Burr. Annual. Common. Adventive from the western plains. (Ringgold Co., 1890, Rutledge.)
- 201. S. citrullifolium A. Br. Citron-leaved Nightshade. Annual. Infrequent. Adventive from the southwest. (Fayette Co., 1893, Fink.)
- 202. S. jamesii. Torr. Wild Potato. Perennial. Rare; an escape from cultivation and probably no longer to be found in the state. Native of the Rocky Mountains. (Story Co., 1898, Sample.)
- 203. Physalis ixocarpa Brotero. Tomatillo. Annual. Escaped from cultivation. Native to our Southwest. (Dickinson Co., 1923, Cratty.)
- 204. P. alkekengi L. Winter Cherry, Chinese Lantern. Perennial. Rare as an escape from cultivation. Introduced from China. (Pottawattamie Co., 1924, Felter.)
- 205. Lycium halimifolium Mill. (L. vulgare, Dunal.) Matrimony vine. A shrubby plant frequently escaped. Introduced from Europe. (Marshall Co., 1902, Pammel.)
- 206. Datura stramonium L. Jimson Weed, Thorn Apple. Annual. A rank smelling plant. Frequent. Naturalized from Asia. (Emmet Co., 1882, Cratty.)
- 207. D. tatula L. Purple Thorn Apple. Annual. Infrequent. A purple-flowered and purple-stemmed form by some authors included in the preceding. Naturalized from Asia. (Fayette Co., 1894, Fink.)

SCROPHULARIACEAE

- 208. Verbascum thapsus L. Common Mullein. Velvet Dock. Biennial. Common. Naturalized from Europe. (Winneshiek Co., 1881, Holway.)
- 209. V. blattaria L. Moth Mullein. Biennial. Rare. Introduced from Europe. (Johnson Co., 1894, Fitzpatrick.)
- Linaria vulgaris L. Toad Flax, Butter-and-Eggs. Perennial. A common escape. Naturalized from Europe. (Story Co., 1883, Hitch-cock.)
- 211. L. minor L. (Chaenorrhinum Lange). Smaller Toad Flax. Annual. Very rare. Adventive from Europe. (Chickasaw Co., 1924, Spiker.)

- 212. Antirrhinum majus L. Snapdragon. Perennial. A frequent escape. Introduced from Europe. (Boone Co., 1924, Pammel.)
- 213. Veronica arvensis L. Corn Speedwell. Annual. Frequent. Naturalized from Europe. (Johnson Co., 1889, Hitchcock.)
- 214. V. tournefortii C. C. Gmelin. (V. persica Poir.) Speedwell. Annual; rare. Adventive from Europe. (Chickasaw Co., 1926, Spiker.)

PLANTAGINACEAE

- 215. Plantago eriopoda Torr. Plantain. Perennial. Rare. Adventive from the northwest. (Story Co., 1913, Anderson.)
- 216. P. lanceolata L. Buckhorn. Perennial. A common pernicious weed. Naturalized from Europe. (Story Co., 1890, Sirrine.)

RUBIACEAE

- 217. Galium verum L. Yellow-flowered Bedstraw. Perennial. Rare. (Cass Co., 1925, Sorden.)
- 218. Diodia teres Walt. Button Weed. Annual. A rare plant, introduced from the South. (Story Co., 1927, Lounsberry.)

CAPRIFOLIACEAE

- 219. Lonicera tatarica L. Tartarian Honeysuckle. Shrub, introduced from Asia, and an occasional escape. (Fayette Co., 1894, Fink.)
- 220. L. sempervirens L. Trumpet Honeysuckle. Shrubby plant; rare as an escape. Native further east and south. (Chickasaw Co., 1925, Spiker.)
- 221. Symphoricarpos racemosus lacvigatus Fernald. (S. albus laevigatus Blake.) Snowberry. Low shrub. Rare as an escape. Native further north and northeast. (Webster Co., Paige.)

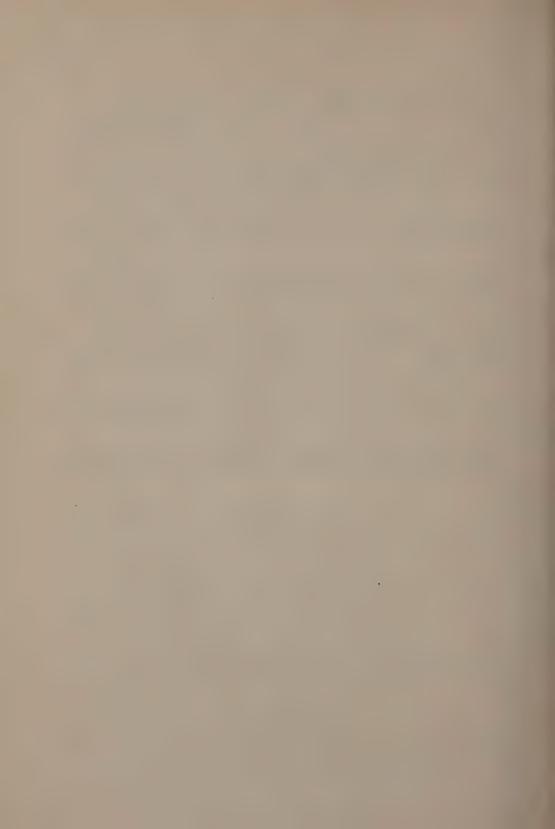
COMPOSITAE

- 222. Inula helenium L. Elecampane. Perennial; naturalized from Europe. A rare escape. (Johnson Co., 1895, Fitzpatrick.)
- 223. Xanthium spinosum L. Spiny Cocklebur, Annual. Rare. (Story Co., 1927, Smith.)
- 224. Helianthus annuus L. Common Sunflower. Annual, cultivated and a frequent escape. Native from Saskatchewan to Texas and westward. The wild form is by some referred to as H. lenticularis Dougl. (Winneshiek Co., 1879, Holway.)
- 225. *H. petiolaris* Nutt. Prairie Sunflower. Annual; frequent. Native of the western plains and probably introduced in Iowa. (Muscatine Co., 1894, Reppert.)

- 226. Coreopsis tinctoria Nutt. Coreopsis. Annual. Frequent as an escape. Native further west and south. (Story Co., 1892, Burgess.)
- 227. Galinsoga parviflora hispida DC. Galinsoga. Annual; infrequent. Adventive from South America. (Mitchell Co., 1913, Tuttle.)
- 228. Achilleia millifolium L. Milfoil, Yarrow. Perennial; frequent. Adventive from Europe. Less common than the next species. (Chickasaw Co., 1890, Rolfs.)
- 229. A. lanulosa Nutt. Milfoil. Perennial; common. Native from Saskatchewan to New Mexico and westward; becoming common further east. The difference between these two species hardly warrants their being kept separate. (Winneshiek Co., 1881, Holway.)
- 230. Anthemis cotula L. May Weed, Dog Fennel. Annual. Very common around homesteads. Naturalized from Europe. Winneshiek Co., 1881, Holway.)
- 231. Matricaria suaveolens (Pursh) Buchenau. (M. discoidea DC.) Wild Chamomile. Annual. Frequent. Adventive from the Pacific Coast. (Cerro Gordo Co., 1908, Pammel.)
- 232. Chrysanthemum leucanthemum L. White Weed, Ox-eye Daisy. Perennial, common. Naturalized from Europe. A variable plant. (Winneshiek Co., 1881, Holway.)
- 233. Tanacetum vulgare L. Tansy. Perennial. An occasional escape from cultivation. Introduced from Europe. (Fayette Co., 1893, Fink.)
- 234. Artemisia abrotanum L. Old Man, Southern Wood. Perennial. Rare as an escape. Introduced from Europe. (Mitchell Co., 1913, Tuttle.)
- 235. A. annua L. Annual Wormwood. Frequent. Naturalized from Europe. (Decatur Co., 1898, Fitzpatrick.)
- 236. A. absinthium L. Wormwood. Perennial, shrubby. An occasional escape. Naturalized from Europe. (Central Iowa, 1925, Wilkinson.)
- 237. Arctium minus Bernh. Smaller Burdock. Biennial, very common. Naturalized from Europe. (Winneshiek Co., 1879, Holway.)
- 238. A. minus tomentosum (Mill.) Gay. Woolly Burdock. Biennial. Very rare. (Emmet Co., 1892, Wolden.)
- 239. Echinops sphaerocephalus L. Globe Thistle. Perennial. Very rare. Adventive from Europe. (Clay Co., 1923, Willard.)

- 240. Carthamus tinctorius L. Saffron. Annual; rare. A spiny-leaved plant, perhaps not persistent. Adventive from Asia. (Sac Co., 1927, Rogers.)
- 241. Carduus acanthoides L. Annual or biennial. Smaller Musk Thistle. Rare. Adventive from Europe. (Calhoun Co., 1911, Hartley.)
- 242. C. nutans L. Musk Thistle. Biennial; infrequent. Adventive from Europe. (Sac Co., 1894, Posey.)
- 243. C. lanceolatum L. Bull Thistle. Biennial. Frequent in pastures and along highways. Naturalized from Europe. (Lee Co., 1891, Rolfs.)
- 244. C. arvense (L.) Scop. Canada Thistle. Perennial. A pernicious weed, becoming very common. Naturalized from Europe. (Emmet Co., 1895, Canon.)
- 245. C. arvense mite Wim. & Grab. Canada Thistle. Perennial. A rare form with entire leaves. Introduced from Europe. (Central Iowa, 1921.)
- 246. Onopordon acanthium L. Cotton or Scotch Thistle. Annual or biennial; infrequent. Adventive from Europe. (Fayette Co., 1925, Farm Bureau.)
- 247. Centaurea solstitialis L. Barnaby's Thistle. Annual. A common weedy plant. Naturalized from Europe. (Greene Co., 1903, Sundell.)
- 248. C. jacea L. Brown Knapweed. Perennial; infrequent. Adventive from Europe. (Cherokee Co., 1924, Ellis.)
- 249. C. cyanus L. Corn Flower, Blue Bottle. Annual. A common escape. Introduced from Europe. (Story Co., 1904, Pammel.)
- 250. C. maculosa Lam. Spotted Knapweed. Annual or biennial; infrequent. Adventive from Europe. (Hamilton Co., 1922, Catlin.)
- 251. C. nigrescens Willd. Black Knapweed. Perennial; rare. Adventive from Europe. (Calhoun Co., 1911, Hartley.)
- 252. Cichorium intybus L. Chickory, Blue Sailors. Perennial. Frequent along roadsides. Naturalized from Europe. (Fayette Co., 1893, Fink.)
- 253. Picris echioides L. Ox-tongue. Annual or biennial; rare. Adventive from Europe. (Clarke Co., 1924, Agans.)
- 254. Tragopogon pratensis L. Goat's Beard. Biennial or perennial; frequent. Introduced from Europe. (Story Co., 1894, Stewart.)

- 255. Taraxacum officinale Weber. Dandelion. Perennial. Very common. Naturalized from Europe. (Hardin Co., 1873, Cameron.)
- 256. T. erythrospermum Anderz. Red-seeded Dandelion. Perennial. Less common than the preceding. Naturalized from Europe. (Story Co., 1918, Cratty.)
- 257. Sonchus arvensis L. Perennial Sow Thistle. Frequent, a pernicious weed. Naturalized from Europe. (Greene Co., 1898, Tomson.)
- 258. S. oleraceus L. Sow Thistle. Annual; very common. Naturalized from Europe. (Johnson Co., 1887, Hitchcock.)
- 259. S. asper L. Sow Thistle. Annual; frequent. Naturalized from Europe. (Floyd Co., 1874, Arthur.)
- 260. Lactuca scariola L. Prickly Lettuce. Annual or winter annual; common. Naturalized from Europe. (Shelby Co., 1913, Pammel.)
- 261. L. virosa L. (L. scariola integrata Gren. & Godr.) Prickly Lettuce. Annual or winter annual. Too near the preceding. Naturalized from Europe. (Wright Co., 1894, Pammel.)
- 282. Crepis tectorum L. Hawk's Beard. Annual; rare. Adventive from Europe. (Marshall Co., 1926, Walker.)
- 263. Hieracium florentinum All. King Devil. Perennial; a harmful weed; infrequent. Adventive from Europe. (Butler Co., 1920, Crowgey.)



BIOLOGICAL STUDIES OF PSEUDOMONAS TUMEFACIENS SM. & TOWN. AND FIFTEEN RELATED NON-PATHOGENIC ORGANISMS*

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INTRODUCTION

Riker and Keitt (21), in their isolation studies in 1925 on 175 pieceroot grafted apple trees with overgrowths at the union, failed to obtain an organism which would produce crown gall when inoculated into tomato plants. Later, the same investigators (22) (23), extending their isolation trials to include 227 trees similarly affected, were able to recover *Pseudomonas tumefaciens* Sm. and Town. from less than two per cent of the specimens. In isolation trials made by Muncic (15) (16) in 1925 and 1926 on piece-root grafted nursery apple trees, showing the typical "wooly knot" type of overgrowth at the union, the crown gall organism was recovered from 23 of the 196 trees tested.

Further isolation trials were made by Riker and Keitt (24) on 180 apple trees similar to those employed in their preceding studies. Of this lot, 24 trees showed characters of both wound overgrowth and crown gall. Ps. tumefaciens was recovered from 21 of the trees studied.

It is significant to note that these investigators were unable, in a majority of cases, to recover *Ps. tumefaciens* from the "woolly knot" type of overgrowth at the union. However, they obtained many bacterial colonies closely resembling *Ps. tumefaciens*, which upon inoculation into tomato plants and other hosts, failed to produce crown gall.

The data presented by Muncie (15) show that organisms, non-patho-

The data presented by Muncie (15) show that organisms, non-pathogenic on tomato, but closely resembling *Ps. tumefaciens* were obtained from 77 of the 196 trees used in isolation trials. Riker and Keitt (24) also obtained from the interior of certain wound overgrowths, organisms which produced colonies on agar plates resembling those of the crown gall bacteria. These organisms failed to produce infection on tomato (*Lycopersicon esculentum Mill.*), geranium (*Pelargonium hortorum Bailey*), tobacco

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These studies have been carried out in connection with the crown gall project in which the Crop Protection Institute of the National Research Council, University of Wisconsin, U. S. Department of Agriculture, Office of Mycology and Disease Survey, and Iowa State College are cooperating.

(Nicotiana tabacum L.) and apple (Pyrus malus L.) and were regarded by them as soil bacteria which survived in the convolutions of the tissues of the wound overgrowths. That such organisms exist in association with galls has been repeatedly shown by Smith, Brown and Townsend (28), who, in many cases, were unable to obtain infection from organisms closely resembling Pseudomonas tumefaciens taken from overgrowths on young apple trees.

These findings raised the question as to the origin of the overgrowths at the union of the piece-root grafted apple trees and that of the significance of the organisms resembling Ps. tumefaciens taken from these malformations. It is proposed in this paper to present the results of biological studies involving 15 non-pathogenic organisms obtained in isolation trials upon some 200 overgrowths of the "woolly knot" type on piece-root grafted young apple trees. These studies include a comparison of the morphology, pathogenicity, cultural and chemical and serological agglutination reactions of the 15 organisms with those of different strains of Ps. tumefaciens of known virulence.

SOURCE OF THE CULTURES EMPLOYED

The 15 non-pathogenic cultures used in this study were supplied by Dr. J. H. Muncie, of this laboratory. With two exceptions, they were obtained while making isolations from overgrowths on nursery stock. The following descriptions, supplied by Dr. Muncie, are summarized in table 1.

TABLE 1. Description of the 15 non-pathogenic organisms used in cultural studies.

		Diagno	sis of over	growths	
Culture	Host	Crown	Callus	Hairy	
number	plant	gall	knot	knot	Where collected
15	Bean	9			Iowa
27	Apple	+			. 29
33	Peach	+			Tennessee
43	Apple		+		Nebraska
50	797				27
98	2)			+	New York
116	22			+	Missouri
119	27				>>
121	"			+	23
123	"			+	. 23
130	22	+			Indiana
133	"		+ 1		Iowa
139	"		+		2)
162	22			+	Missouri
174	"		+		Iowa
1080*	Almond	+			California

^{*}Culture number 1080 was obtained through the courtesy of Prof. C. O. Smith, Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.

MORPHOLOGICAL AND CULTURAL STUDIES

The morphology of the 15 non-pathogenic organisms and one pathogenic strain (R) of the crown gall organism isolated from raspberry was studied in 24 hour cultures grown on neutral potato dextrose agar at room temperature. Baggett's method was used in making the Gram stain. A 24 hour culture of *Bacillus subtilis* (Ehr.) Cohn was used for comparative

purposes. With the exception of *B. subtilis* all the organisms tested proved to be gram negative. The organisms were readily stained with carbol fuchsin, methylene blue and gentian violet. They were found to be non-chromogenic and non-acid fast. Morphologically, the non-pathogenic organisms were indistinguishable from *Pseudomonas tumefaciens*. Involution forms were found in all old cultures except number 15 and *Bacillus subtilis*. Motility was studied, using the Hasse method. Duplicate tests showed all forms to be motile. Microscopic examination by the hanging drop method also showed that all the organisms were motile. The motility of these organisms was also demonstrated by staining the flagella by Van Ermengem's method. The organisms were found to be motile by uni-polar flagella, usually only one, occasionally two and rarely three. Brooks, Nain and Rhodes (3) report three strains of *Pseudomonas tumefaciens* which were non-motile.

All the organisms were short, slender rods. They were mostly single, sometimes in chains of twos or threes, but never more. With the exception of Bacillus subtilis, none of the organisms showed spore formation. Ten representative organisms of each strain were measured accurately. The range of variations in the entire group was 0.5 to 2.5x0.3 to 0.6μ (table 7). It should be stated that Rosen (26), Levine (12), Walkden (30), Riker (19) and Smith and his co-workers (28) also have noted slight morphological and physiological differences in the crown gall pathogens with which they worked.

CULTURAL CHARACTERS

On agar poured plates. On poured plates of neutral beef agar, the small, circular, white, almost flat colonies appear within 48 hours. The agar remains unchanged and no odor is present. The growth on this medium is not so vigorous as that on media containing a small amount of dextrose.

On poured plates of neutral potato dextrose agar, the colonies show more vigorous growth than upon any other medium. The colonies are circular, white, translucent, shining, raised and generally possess a more or less definite, darker center. The colonies appear on this medium within 24 to 48 hours. The color of the medium remains unchanged and no odor is present.

On poured plates of crystal violet bile agar at room temperature, the colonies appear within 48 hours. The growth on this medium is more abundant than that on beef agar. The colonies are cicular, raised, translucent, white, shining and possess a more or less definite darker center. In this and other media, the buried colonies are lens-shaped, white and remain small until they reach the surface. The color of the medium remains unchanged and no odor is present.

On agar slants. Cultures were streaked on neutral potato dextrose agar and readings recorded after 48 hours. All the cultures gave a white, glistening, smooth, non-chromogenic, translucent, filiform and good growth, with the medium unchanged. However, the following differences in the growth of the cultures were noticed: cultures numbers 121 and 50 gave less abundant growth than the others.

Gelatin liquefaction. Frazier's (7) method of qualitative determination of proteolysis was used. The medium consists of 1.5 per cent agar, 0.4 per cent gelatin, 0.1 per cent peptone and 0.2 per cent dipotassium phosphate. After a good growth of the organism has been secured, one of the two plates is flooded with an acidified 1-500 aqueous solution of mercuric chloride. A clear zone around the colony indicates liquefaction of the gelatin. The other plate is flooded with one per cent tannic acid solution and if liquefaction has taken place a clear halo forms immediately surrounding the colony with a striking, white, precipitated halo surrounding the clear area. Cultures numbers 121, 123, 139 and 162 showed characteristic gelatin liquefaction in both plates, while all others gave negative results.

Indol production. None of the cultures showed indol production after seven days when tested with potassium nitrite and sulfuric acid. Smith, Brown and Townsend (28) obtained slow indol production with Pseudomonas tumefaciens.

Cohn solution. The growth in Cohn solution was very scant. Cultures numbers 119 and 123 showed extremely poor growth and with the remainder the growth was doubtful or absent.

Uschinsky solution. The growth in this solution was little better than that in Cohn solution. The cultures numbers 33, 162, 15, 133, 123, 27 and 50 gave some growth, though not abundant. The remainder of the cultures gave doubtful or very scanty growth.

H-ion concentration. A series of tubes of beef peptone agar was adjusted with normal hydrochloric acid and sodium hydroxide to the following pH values: nine, eight, seven, six and five. The pH values of the different media were determined colorimetrically, comparing them with standard colors. To the medium of each pH series was added the indicator to note the change. The results of these trials are presented in table 2. Although the data presented show that the organisms tolerate hydrogen-ion concentrations of five on the acid and nine on the alkali side, the maximum growth was obtained when the medium was neutral.

Thermal death point. In determining the thermal death point, a series of test tubes with walls of uniform thickness containing five c.c. nutrient broth was exposed to temperatures of 55° and 65°C. in a water bath. After the temperature of the medium had become constant, a loopful of the suspension from a 24 hour peptone dextrose broth culture was transferred to these tubes without touching the sides and held at the specific temperature for 10 minutes. After the exposure the tubes were cooled at once and left at room temperature for four days. All cultures showed no growth after exposure at 55° and 65°C. This indicates that the thermal death point of the organism in question is below 55°C, and that all are probably non-spore formers. Smith, Brown and Townsend (28) reported 51°C, to be the thermal death point of Ps. tumefaciens, while Walkden (30) found it to be 46°C.

Loeffler's blood serum. The cultures were streaked on standard Loeffler's blood serum slants and kept at room temperature for 13 days. Growth

TABLE 2.	Toleration of H-ion	concentration by two strains of Pseudomonas tur	me-
		d 15 non-pathogenic organisms.	

			pH range		
Culture	9	8	7	6	5
$\mathbb{R}^{\mathbf{a}}$	*2-3	3	4	3	3
15	2-3	3	4	3	3
27	2-3	3	4	3	3
33	2-3	3	4	3	3
43	2-3	3	4	3	3
50	3	3	4	3	3
98	2-3	3	4	3	3
116	2-3	3	4	3	3
119	2-3	3	4	3	3
121	2-3	3	4	3	1
123	2-3	3	4	3	3
130	2-3	3	4	3	3
133	3	3	4	3	3
139	2-3	3	4	3	3
162	2-3	3	4	3	3
174	2-3	3	4	3	3
1080°	2-3	3	4	3	3

^{*1=}scanty growth

was fair, although it was not so good as that on potato dextrose agar. None of the cultures liquefied the medium, although the medium of culture 139 became drab in color.

Hydrogen sulfide. The production of hydrogen sulfide was tested in lead acetate agar poured plates, and the results were recorded after six days' incubation at room temperature, when a heavy growth of the organism was noted. All of the cultures produced slight blackening of the agar.

Action on starch. All the organisms, after four days' growth, gave the medium a dark blue color when flooded with a saturated solution of iodine in 50 per cent alcohol, indicating that there had been no diastatic action on the starch. Smith, Brown and Townsend (28) reported that the diastatic action of the crown gall pathogen was feeble or absent. Walkden (30) also reported the pathogen attacking starch feebly.

Litmus milk. Cultures numbers 162, (R), 121, 27, 123, 1080, 50, 15. 174, 133, 130, 98, 33, 119 and 139 showed entire reduction of litmus and partial digestion of milk in one week. After standing another week numbers 162, 121 and 139 showed entire digestion of milk. Check tubes of uninoculated litmus milk showed no change during the entire period.

Plain milk. As in the case of litmus milk, a few minor differences between the various organisms were noted. All the cultures digested part of the plain milk. In cultures numbers 43 and 133 a slight pink tinge was noticed, while number 15 was slightly lighter in color and 27 showed slightly darker color. Except for these changes in the medium, no sharp distinctions were noted among cultures of the different organisms.

Reduction of nitrates. In triplicate trials using potassium nitrate broth none of the cultures reduced nitrate to nitrite. It may be mentioned

²⁼fair growth

³⁼medium growth

⁴⁼good growth
* Strains of Ps. tumefaciens.

here that cultures numbers 27, 50, 43, 15, 174, 162, 98, (R), 119, 123 and 139 have a tendency to absorb NO_2 from the air so quickly that the suspensions turn pink five minutes after the additions of the test solutions. None of the cultures produced gas.

Beef broth. All the cultures gave moderate growth with more or less flocculent sediment after the fourth day. The following minor differences were noted: formation of a good pellicle was observed in cultures numbers 139, 133, 15 and 50, while 1080, 174, (R), 98, 123, 121, 43, 130 and 162 showed a very faint pellicle. All of them gave slight to moderate clouding upon shaking.

Voges-Proskauer and methyl red tests. None of the cultures gave a positive test for acetyl methyl carbinol, which is typical of the Voges-Proskauer reaction. All the cultures gave a negative reaction upon addition of the methyl red indicator. In these trials the methyl red reaction did not correlate with the Voges-Proskauer reaction.

Oxygen requirements. The cultures were made on nutrient beef agar. Pyrogallic acid and sodium hydroxide were used to exhaust the oxygen from the tubes. The tubes were then kept at room temperature. Examinations made after four days showed no growth of any of the cultures, thus indicating that the organisms are aerobic. After six days, the tubes were emptied of acid and alkali and kept for three more days at room temperatures for growth. All cultures showed some growth. These experiments show that the organisms have a tendency to be aerobic, but they are not completely killed in the absence of oxygen within the time specified.

Ccllulose medium. In attempting to determine the taxonomic position of these organisms the writer questioned whether or not they might be cellulose decomposers, which are generally inhabitants of soils and which

resemble certain of the plant pathogens in many respects.

A medium was, therefore, made in which the only carbohydrate supplied was cellulose in the form of absorbent cotton. A trace of dipotassium phosphate and of ferric sulfate supplied the inorganic nutrients, which were added to a two per cent agar. The cultures, which were streaked and incubated at room temperature for 27 days, showed no growth, and no coloring of the medium occurred, indicating that these organisms are not cellulose decomposers. Rhizobium leguminosarum Frank (the check) alone decomposed cellulose in 35 days when Omelianski's medium was used. Cellulose decomposition began in the check cultures in about a week from the day of inoculation.

From the results of the morphological and cultural studies of these organisms, summarized in table 3, it is evident that the non-pathogenic forms are indistinguishable from the pathogenic strain of *Pseudomonas*

tumefaciens.

Carbon metabolism. To test for acid and gas production, one or more members of the monosaccharides, disaccharides, trisaccharides and polysaccharides in nutrient bouillon were used. Instead of the ordinary U tubes, a simpler and more convenient type of fermentation tube, consisting of a small test tube 0.5x5.0 cm. inverted within a larger one, was employed.

In almost all cases very good growth occurred in the media after three days. No gas was produced.

Acid production from carbon compounds. To determine the production of acids from these carbohydrates, two sulphonphthalein indicators, brom thymol blue and phenol red, were used. The indicators serve for a pH range of six to eight. With the addition of these indicators to the medium, slight amounts of acid or alkali produced by the organisms in sugar broths may be detected.

None of the cultures produced both acid and gas after 14 days, but most of them produced more or less acid. The data on fermentation of the carbon compounds, dextrose, saccharose, glycerol, maltose, xylose, rhamnose, raffinose, levulose, lactose, dextrin, mannitol, sodium eitrate, sodium

tartrate and salicin are presented in table 4.

Bacterium coli, which produces gas and acid in all the sugars employed, was grown as a check. Wherever doubt existed as to the production of acid, a notation to this effect has been made in the table. Cultures 121 and 123 are examples of this type. It is also true of these organisms that they produce alkalinity in certain compounds, especially dextrin, raffinose, sodium citrate and sodium tartrate.

AGGLUTINATION STUDIES

Since the morphopoligical and cultural tests did not give a clear cut difference between the non-pathogenic organisms and the two strains of *Pseudomonas tumefaciens*, chemical agglutination was tried as a possible means of differentiation.

CHEMICAL AGGLUTINATION TESTS

It has been shown by Berridge (1) that chemical agglutination tests were just as specific as those in which serum was employed. In the light of her findings, chemical agglutination tests were made as a possible means of differentiating the fifteen non-pathogenic organisms from Ps. tume-faciens.

In the first trials, the non-pathogenic organisms were compared with five strains of *Ps. tumefaciens* in their reactions with Al₂ (SO₄)₃ and Th (NO₃)₄ (tables 5 and 6). In further trials (table 7), the chemical agglutination tests were made, employing 18 strains of the crown gall organ-

ism and one strain of B. radiobacter Beij. using Th (NO₃)₄.

In making the antigen suspensions, sterile distilled water was used. After the addition of the antigens to the diluted chemical solutions, the tubes were shaken well and incubated at 37.5°C. for two hours, after which the preliminary results were recorded. After leaving the tubes at room temperature for two hours longer, the final data, which are presented in tables 5 and 6, were recorded.

In the following tables, the figures 0, 1, 2, 3 and 4 represent the degree of agglutination; 0 showing no agglutination, 1 slight agglutination, 2 me-

¹This culture of *Bacillus radiobacter* was obtained from the Soils Department of Iowa State College through the courtesy of Dr. F. B. Smith.

TABLE 3. Morphological and cultural characters of the 15 non-pathogenic organisms and Pseudomonas tumefaciens.

			Pathogenicity	+ +
			PH tolerance	6-9-
			death point	Below 55°C
	40	1	Plain Thermal	Partly digested
	Milk	-	Litmus	Partial reduction and digestion
			requirement	
	_		аттаскед Охуgеп	+++++++++++++++++++++++++++++++++++++++
			Stareh	
ology			Nitrate reduction	
			Gelatin Jiquefaction	++ ++
Physiology	Production	of	StH	1 + + + + + + + + + + + + + + + + + + +
	Prod		ІориІ	
	-		M. R. tests	
-			V. P. tests	
			Cellulose decomposition	
	h in		Loeffler's blood serum	+++++++++++
	Growth		Cohn's sol.	
			Uschinsky's solution	
			Width ni microns	လ် လံ ရ 4
)gy			Length ni snorsim	F: F: 0 \otimes \otime
Morphology			Motility	++++++++++++
Tol			Chromogenie	
			Form	
			Assl bish	
	ins		Endospore	
	Stains		Spore	3
			mrıt	
			Culture No.	R* 115. 27. 27. 27. 27. 27. 27. 27. 27. 27. 27

B=Browning of the medium.
 ±=Heavier darkening of the medium.
 Strains of Ps. tumefaciens.

Reactions of the 15 non-pathogenic organsms and Pseudomonas tumefaciens in broths containing various carbohyrates, alcohols, organic acids and glucosides. TABLE 4.

	Patho-	4	- 1	1	1	1]	1		1		1	1	1]	1	1	+
	Sali-	A	∀	A	A	A	A	A	A	A	A	A	A	Ą	A	A	A	4
	Sodium tar-	A1	A1	A1	A1	A1	A1	Δ1	Al	A1	A1	A1	A1	A1	A1	A1	A1	A1
	Sodium	A1	A1	A1	A1	A1	Al	A1	A1	A.1	Al	A1	A1	A1	A1	A1	A1	A1
	Man-	A	A	A	A	4	A	Y	As	A	A	(300	A	A	As	As	A	A
ii	Raf-	Ą	As	As	As	V	A8	A	As	As	Als	Ψ1	As	A	As	A	Λ1	As
Reactions	Dex-	Als.	A	(3r4)	3:+	V	A	A	Qo.	9>+	Als	Als	A	Als	A	V	Als	920
	Lac- tose	A	A	¥.	¥	A	Ą	A	A	A	G>+	G:•	V	A	¥	Λs	V	4
	Levu- lose	A	Ą.	Α.	Ą	A	V.	Ą.	Ą	A	As	¥	A	A	¥	Ą	¥	A
	Rham- nose	A	¥.	Α.	¥.	¥.	Ą	A.	¥	¥	¥	Ą	4	A	¥.	A	As	A
	Xy- lose	A	₹,	>⊶ €	300 .	A.	₽.	₹,	30°	Ą	₩,	300	¥.	Ą	¥.	۷.	¥.	A
	Mal- tose	A	Α.	A.	Ą	A,	As	Ą	A.	A.	Als	As	¥.	¥.	¥ .	A .	< -	A
	Gly- cerol	V	A ·	₩ *	4	¥ -	₩-	4.	As	¥.	AS	As	¥ -	۷.	As	A.S	Δ.	A
	Sac- char- ose	Ą	4	<1 ≺	₽,	₹ -	₹,	ಷ -	₫ -	۷°	jor () io	¥÷	۷,	¥,	₹,	A,	V
	Dex- trose	Y.	4	4	t! ~	4	4; <	4	₹*	¥ +	¥ *	₩ •	A.	4	V	4	<	W
	Culture No.	*41	1.0	150	200	3 to 10	000	110	110	113	100	120	100	100	163	107	*/J	TOON.

A=Aeid.

As=Slight acid, f=Doubtful as to acid production.

A1=Alkaline.
A1s=Slightly alkaline.
*Strains of Ps. tumefaciens.

dium agglutination, 3 almost complete agglutination though the liquid remained slightly cloudy and, 4 complete agglutination, the supernatant liquid remaining quite clear.

The data show that the agglutination titre in Th $(NO_3)_4$ is much higher than that in $Al_2(SO_4)_3$. However, no major differences between the

cultures are brought out by either of the salts.

Chemical agglutination tests using Th (NO₃)₄ were also made with 18 virulent strains of the crown gall pathogen obtained from various plants and one strain of B. radiobacter. The results presented in table 7 support the conclusions reached before, namely, that chemical agglutination tests are, at best, a poor means of differentiating one strain from another. It is true that only known substances are dealt with in chemical agglutination and that there is no such complexity present as in the case of immune sera. Thus, while the results presented indicate a close physiological relationship between several non-pathogenic organisms and strains of the crown gall organism, yet these tests failed to differentiate the non-pathogenic organisms from Pseudomonas tumefaciens. This led to serological agglutination studies.

SEROLOGICAL AGGLUTINATION TESTS

Since the chemical agglutination tests were inadequate for differentiating the pathogenic strains of *Ps. tumefaciens* from non-pathogenic organisms, further tests were made with immune sera. Serum agglutination tests for differentiating types of diseases and bacterial species have been extensively employed in bacteriology. Such tests have been recently employed in plant pathology by Paine and Lacey (17), Goldsworthy (8), Link and Hull (14), Link and Sharp (13), Sharp (27) and others. Therefore, use of such a means of differentiation was made in these studies.

Paine and Lacey (17) tried to differentiate Bacillus lathyri M. & T., Pseudomonas phaseoli Sm. and Bacterium michiganense Sm. by serological agglutination tests. The first two organisms showed only group agglutination and Bact. michiganense failed to produce immune serum. However, they concluded that these organisms could be separated by agglutination tests. Lacey (11) and Berridge (1), working with serum and chemical agglutination, respectively, of three plant pathogenic bacteria, Bacillus carotovorus Jones, B. solanisaprus Harrison and B. atrosepticus Van Hall, found enough differences among the species to separate them by these tests, and have shown that chemical agglutination in these cases is just as reliable as serum agglutination.

Doidge (4) found that the immune serum produced against Pseudomonas citrimaculans Doidge, agglutinated its homologous strain to a titre of 1-2000. Sharp (27) working with the three morphologically similar organisms, Ps. flaccumfaciens Hed., Ps. phaseoli Sm., and Ps. phaseoli sojense Hed., found that these organisms could be distinguished by means of serological agglutination tests. Link and Sharp (13) demonstrated that Ps. campestris (Pam.) Sm., Ps. phaseoli, Ps. phaseoli sojense and Ps. flaccumfaciens could be differentiated by serological agglutination tests, al-

though these organisms are closely related to each other.

Goldsworthy (8) applied the agglutination tests in identifying the cauliflower spot disease organism, Ps. maculicola McC, when isolated from

Chemical agglutination tests using Th(NOs), against 15 non-pathogenic organisms and two strains of Pseudomonas tume-TABLE 5.

	Patho-genicity on toma-	to plants	+	1	1	1		1	1	1	1	!	1	Bernar	1	1	-	1	+1	+	+	+
	Original	host	Raspberry	Bean	Apple	Peach	Apple	37	2	73	23	23	20	33	29	99	39	23	Almond	Rose	Prunus	Rumex
		Ck.		I	1	maxim	ļ	1	Į	-	-	-	1	Į	1				1	1		ļ
		1-10240	-	-				-	-	1	1		1		-	63			r-i	-	-	
			33	01	03	27	C1	67	63	-		- Designation of the last of t	-	671	ಣ	6.1	01		03	ಣ	67	_
		1-2560 1-5120	000	co	ಯ	87	3	673	റ	က	က	03	63	က	es	က	က	63	က	4	ಣ	ಣ
•	. 9:	1-1280	7	63	-11	23	3	ಣ	60	6.2	ಣ	63	ಣ	4	3	ಣ	ന	m	က	÷	ಣ	٠٠:
	ation titl	11-640	4	4	4	4	4	4	ಣ	ಣ	4	ಣ	4	4	4	4	4	623	4	4	4	4
	Agglutination titre	1-320	4	4	4	4	4	4	4	4	4	က	4	4	4	4	4	4	4	4	4	4
		1-160	4	4	4	4	4	#	4	4	4	4	4	4	4	4	4	4	4	4	#	4
		1-80	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		1-40	4	4	4	4	4	4	4	#	4	4	4	4	4	4	4	4	4	4	A.	4
		1-20	41	ᆉ	4	-41	4	4	4	4	4	Ť	4	4	4	4	4	4	4	4	4	+
		1-10	ᆌ	44	4	4	41	4	4	4	41	4	4	41	41	4	4	4	4	4	4	4
	Culture	No.	***	15	27	က	43	20	98	116	119	121	123	130	133	139	162	174	1080*	5113*	1142*	374*

*Strains of Ps. tumefaciens.

Chemical agglutination tests using Al₂(80,), against 15 non-pathogenic organisms and two strains of Pseudomonas tume-faciens. TABLE 6.

Patho-genicity on toma-	to plants	+	1	1	1	1	1	-	-	1	1	1	-	1			1	+1	+	+	+
Original	host	Raspberry	Bean	Apple	Peach	Apple		33	8	8	39	. 66	23	33	39	2	33	Almond	Rose	Prunus	Rumex
	Ck.	1	1	ĵ	1	1	ļ	1	1	1	į	l	1	1	1]	1	1	1	ţ	1
	1-10240	1		1	1	1	1	1	1		1	1	- Contract of the Contract of	1		1	1	1		1	1
	1-5120	-		H	1	1	1	-	1	†		1	1	1	1	i			1	-	i
	1-640 1-1280 1-2560 1-5120	C3	03	Н	63	c3	-	1			C 3	-	-		6/3			03	1		1
titre	1-1280	4	က	ಣ	4	4	က	ಣ	63	63	c1	c3	ಣ	ಣ	ಣ	က	63	4	ന	ಣ	2
Agglutination titre	1-640	Ŧ	4	4	*	4	4	က	ಣ	က	03	ಣ	က	4	4	4	ಣಾ	4	*	4	က
Agglut	1-320	4	4	4	4	₩.	4	4	4	4	ಣ	ಣ	4	4	4	4	4	4	-4 1	4	က
	1-160	4	4	4	4	4	4	4	4	4	4	ಣ	4	4	4	4	4	4	4	4	က
	1-80	4	4	4	4	4	4	4	4	4	4	4	4	4	7	4	4	4	4	41	4
	1-40	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	41
	1-20	4	7	4	4	4	4	4	4	*	4	4	4	4	4	4	4	4	4	4	4
	1-10	4	4	4	4	41	4	4	4	4	4	4	7	4	4	7	4	4	4	4	4
Culture	No.	R*	15	27	33	43	50	98	116	119	121	123	130	133	139	162	174	1080*	511a*	1142*	374*

*Strains of Ps. tumefaciens.

Chemical agglutination tests using Th(NO₃), against 18 virulent strains of Pseudomonas tumefaciens and one strain of Bacillus radiobacter. TABLE 7.

Pathogenicity on tomato	plants	+		-+		-+		-+	-+	-+		-+	-+	+	-+-	+	-+	-+	+		-
Original	host	Apple	37	Rose	Rasnherry	Peach	Apple	Geranium	Apple	33	33	Peach	Walnut	Apple	Rose	Raspherry	Prunus	Raspberry	Incense	Cedar	
	Ck.		1	1	1	į	1	1	1		1	1	1	American	1	1	- Parameter	1	1		ateuna
	1-25600		1	į	1		-	1	1	1	1	1]	Bernelis	1	}	-	1	Ì		-
	1-12800	T	-	1	-	-		1	-	1	H	1	-	1	-	-	-	67		-	61
n titre	1-6400	m	63	: en	ಣ	භ	-	ಣ	ಣ	ണ	ന	es	ಣ	m	4	c 3	C3	c 3	c 3		ಣ
Agglutination titre	1-3200	4	4	4	4	4	4	4	4	4	4	4	4	4	4	m	4	4	4		4
Ag	1-1600	4	4	4	4	4	4	4	41	4	4	4	4	4	4	41	4	4	4	_	4
	1-800	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		41
	1-400	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	41	4	4		4
	1-200	4	4	41	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4
Culture	No.	A	В	1171	ä	1071	1110	1212	1215	1216	1218	1219	1220	1221	1223	1224	1225	1226	1228	B. radio-	bacter

the soil. He concluded that organisms which appeared identical on plates and which gave the same agglutinating titre against immune serum as the pathogen are identical species. No inoculation tests with such organisms were made to prove their pathogenicity.

Friedemann and Magnus (5) obtained numerous strains of bacteria of intestinal and other human diseases which were identical culturally and serologically with Ps. tumefaciens. Friedemann (6), however, showed in a later publication that only one of the numerous identical strains was pathogenic to plants.

Brooks, Nain and Rhodes (3), working on serum agglutination of several phytopathogenic bacteria, found that three strains of Ps. tumefaciens were quite similar, but the daisy strain produced acid in glucose and saccharose, while the other two strains had no effect on these sugars. They found that these three strains of Ps. tumefaciens were non-motile and did not liquefy gelatin. Furthermore, they showed that these reactions were identical with those of Bacillus atrosepticus and that the serum produced from the latter agglutinated Pseudomonus tumefaciens (hop strain) to quarter titre.

Jensen (10) reported that the strain of the crown gall organism isolated from a tumor on a species of chrysanthemum in Denmark resembled the American strain isolated from Chrysanthemum frutescens L. morphologically and culturally, but they differed serologically in that cross agglutination was not possible. However, the serum agglutinated its homologous strain, that is, the American strain was not affected by the serum of

the Danish strain and vice versa.

Link and Hull (14), working with three plant pathogens, Pseudomonas tumefaciens being one of them, showed that the crown gall organism agglutinates spontaneously in distilled water and in 0.85 per cent saline solution.

Riker (19) found that the immune rabbit serum produced against Ps. tumefaciens agglutinated the pathogen up to and including 1-3000 titre. He found no serological identity between the crown gall pathogen and the legume root nodule bacteria.

Serological trials. Injections of a suspension of a 24 hour culture of one non-pathogenic form and one pathogenic strain of Ps. tumefaciens grown on neutral beef agar were made at weekly intervals into a rabbit. The suspension was made by washing the organism from the agar slants with 0.85 per cent saline solution. With one exception, all injections were made intravenously. The last and sixth injection was made intra-peritoncally. The weekly doses were given in the order of 0.5 c.c., 1 c.c., 2 c.c., 3 c.c., 5 c.c., and 5 c.c. Ten days after the last injection, the animals were bled from the heart and about 30 c.c. of blood was obtained. After clotting of the blood had taken place, the entire content of the tube was centrifuged at a high speed for 15 minutes. The clear serum was then transferred aseptically to sterile serum bottles and carbolic acid was added as a preservative in the proportion of 0.1 c.c. of five per cent carbolic acid to each c.c. of the serum. The serum, when not in use, was kept in the ice box.

For the agglutination tests, 24 hour cultures grown on neutral beef agar, were washed in 0.85 per cent saline solution to which 0.4 per cent carbolic acid was added. The carbolic acid, while preventing further growth, in no way hindered the agglutinating power of the sera used. The stock suspensions of the organisms were made so as to obtain the same turbidity as far as possible. Turbidity of the antigens was determined macroscopically by holding the bottles against a glass window. Only antigens of equal turbidity were used during the experiments. Stock antigens were not used after 10 days from the time of their preparation, thus avoiding any discrepancies that might possibly arise due to settling. Fifteen non-pathogenic organisms, twenty-three strains of Ps. tumefaciens (cultures obtained from different hosts or from the same kind of host at different times) and one strain of the organisms, Rhizobium leguminosarum and Bacillus radiobacter were used. In running the agglutination tests, dilutions of 1 in 100, 1 in 200, 1 in 400, 1 in 800, 1 in 1600, 1 in 3200, 1 in 6400, 1 in 12,800 and 1 in 25,600 were made. A cheek tube of stock suspension of organisms was always used for each organism. This technique was followed throughout the agglutination tests, even though none of the organisms was found to be agglutinated spontaneously. The dilutions of sera were made in large bottles, each containing variable dilutions from 1 in 50 to 1 in 12,800, so that when ½ c.c. of this diluted suspension was added to ½ c.c. of the stock antigen, the dilution in the agglutination tubes became 1 in 100 to 1 in 25,600.

After the distribution of the antigen, the tubes were well shaken so that even distribution of the antigen and serum was obtained. The tubes were then placed in incubators at 37.5°C, for two to three hours, after which they were removed and the preliminary readings were taken. The tubes were then left at room temperature over night so that the final results were recorded after 18 hours or more. The results reported in this paper represent the readings after 18 hours, although no marked change from the preliminary readings was observed.

The serum of a normal rabbit was also tested with the cultures, but no agglutination at dilutions of 1 in 100 and upwards was observed. The results of the serum agglutination tests are presented in tables 8 and 9.

The data presented in tables 8 and 9 seem to indicate that both the sera produced against the non-pathogenic organisms and the strains of Pseudomonas tumefaciens are specific for their homologous antigens, in that they both yielded supernatant clear liquid upon agglutination. However, when these sera were interchanged, the agglutination index was not so high as when the homologous antigens were used. This is also true for eight other antigens of the non-pathogenic organisms (27, 43, 50, 98, 116, 139, 162 and 174). In other words, no clear cut difference between these eight antigens of the non-pathogenic organisms and one heterologous strain (which may include Ps. tumefaciens or the non-pathogenic organism) was obtained in these tests. At the same time, six other non-pathogenic organisms (33, 119, 121, 123, 130 and 133) did not yield to agglutination tests, thus differentiating them from the others. The data would have been regular if only one strain of Ps. tumefaciens had been employed in these studies. In that case the non-pathogenic organisms could have been separated into three classes, namely, (1) a homologous strain Ps. tumefaciens (Raspberry) or 15 (non-pathogenic) giving complete agglutination, (2) eight other strains which gave agglutination though not of the same index as (1), and (3) six strains which were non-agglutinable. Agglutination tests were also made with a rough strain (R-1) of Ps. tumefaciens origi-

TABLE 8. Agglutination tests using Pseudomonas tumefaciens (Raspberry strain) antiserum against 15 non-pathogenic organisms,

Culture					Agglutin	Agglutination titre					Original host	Patho- genicity on toma-
No.	1-100	1-200	1-400	1-800	1-1600	1-3200	1-6400	1-12800	1-25600	Ck.		to plants
R*	4	4	4	4	က	ಣ	ಣ	C/1	- American	-	Raspberry	
15	ಣ	භ	ෆ	က	ಣ	67	c ₁	0.7		1	Bean	
27	ಣ	ಣ	ಣ	က	63	63	01	03	1	ŀ	Apple	
33				1		1	1	1	I	!	Peach	
43	හ	က	ಣ	က	က	63	67	H	1	1	Apple	
50	က	ಣ	ක	ന	ಣ	ಣ	0.1	-	!	1	66	
98	4	ရာ	ಣ	ಣ	ಣ	က	62	-	1	Ī	23	400-
116	3	ಣ	က	03	0.1	67	-	1	1	1	22	-
19	i	-		1	1	!	1			1	23	
15	1	1	-	Į	-	-	1	1		1	33	-
62	1	1		1		1	1	1	1	1	33	-
30	1	1				1	-	1]	-	23	
555	i	i		1	1				l	1	33	
39	භ	ന	63	ක	භ	co	C3	l	-	1	33	
62	ಣ	භ	ന	က	က	63	61		İ	1	33	-
74	က	က	ಣ	60	03	H	1	1		1	33	-
*08	1	1		1	1	1]	ļ	Almond	
V*	1	1	I	I	1		1	1	1	1	Apple	
T*	İ	1	1	1	1	1	1	1	1	-	33	
*2	1	1	1	1		1	1	1	1	1	23	
69	1		1]	1	i	1	1	1	Rose	
R-1*	က	က	ന	ಣ	က	67	67	1	-	ì	Raspberry	
1a*	1	1	1	1	1	!		1		1	Rose	
R. leguminosarum		1	1		I	1	1	l	1	1	Pea	
dio hanton	c	c		0	0	0						i

*Strains of Ps. tumefaciens.

Agglutination tests using non-pathogenic organism (culture 15) antiserum against 15 non-pathogenic organisms, eight strains of Pseudomonas tumefaciens and one strain of Bacillus radiobacter and Rhizobium leguminosarum. TABLE 9.

Patho- genicity on toma-	to plants	+	ŀ	-	-	-	1	1	Bentand	1	1	1	1	ł	1	I	1	+1	+	+	+	+	+	+	1	
Original	host	Raspberry	Bean	Apple	Peach	Apple	33	33	33	*	33	**	33	86	*	33	33	Almond	Apple	99	33	Rose	Raspberry	Кове	1	Pea
	Ck.	1	1		1	1	I	1	1	1	1	1		1	Į	-	1	-	1	1	1	1	1		1	1
l l	1-25600	1.	1	1	100000	***************************************	-	1	1	1	1	I	*	1	1	1	1	ı		1	į	1	-		-	_
	1-12800	1		1	1	-		; !	1	1	1	1	1	-1	1	1	1	-	į	-		1	-	1	1	
	1-6400	c3	<u></u>	63	-	c3	c3	c3	-	1	1	1	1	1	-	03	1		1		1	1		1	61	ann tan
tion titre	1-3200	c1	ന	ന		C3	01	C3	1	-		1	1	1	03	C3	1	-	1	-	Manager	1	01	1	က	-
Agglutination titre	1-1600	ന	4	m	1	က	c 3	က	c1		1	1	1	1	67	00	63	-	2-Hamilton	1		1	c1	1	ಣ	-
-	1-800	m	4	ന	1	က	ന	ෆ	61	1	-	1	1		ಣ	ന	ಣ		1	1	1	1	ත		es	-
	1-400	m	4	ന		ന	ಣ	က	භ	1	electric	1	-		ಣ	ಣ	ಣ	-	-	1	1	-	co	1	m	
	1.200	m	4	භ	1	ಣ	ന	ണ	ಣ	-	1		- Contraction of the Contraction	ł	67	ಣ	භ	-	1	1		1	က	1	m	1
	1-100	ಣ	4	භ	1	ಣ	ಣ	00	e	1	1	- management		1	es	භ	en	1	1	1	1	1	69	1	ಣ	1
Culture	No.	*4	15	27	33	43	50	86	116	119	121	123	130	133	139	162	174	1080*	A*	P*	*5	374*	(R-1)*	511a*	B. radiobacter	R. leguminosarum

*Strains of Ps. tumefaciens.

nally isolated from raspberry, but which had been passed many times through tomato and Bryophyllum calycinum Salisb., with Bacillus rabiobacter and with Rhizobium leguminosarum (Pea). The rough strain of Ps. tumefaciens and B. radiobacter yielded the same agglutination index as the eight non-pathogenic organisms, thus showing that these nine nonpathogenic organisms when tested against the original raspberry strain gave an agglutination index which was closely correlated with the rough pathogenic strain of Ps. tumefaciens. Three strains of Ps. tumefaciens obtained from apple galls, two obtained from rose and Rh. leguminosarum gave no agglutination with both sera. Thus, differences even among the strains of Ps. tumefaciens are obtained. The explanation of the variability in the agglutinability of Ps. tumefaciens might be that the crown gall organism shows strain specificity, and that agglutination tests for the identification of this pathogen can not be solely relied upon. The conclusions from such tests in the identification of crown gall organisms might be misleading. Riker (19) and Link and Hull (14), who have employed serological tests with Ps. tumefaciens, used only the homologous antigens and consequently obtained positive results similar to those shown in tables 8, 9 and 10.

Jensen (10) was the first investigator to show that the serum obtained from one strain of the pathogen did not agglutinate another strain obtained from the same kind of host but in a different locality. The possibility, therefore, should not be ignored that the same gall may harbor many strains of Ps, tumefaciens and that the various colonies obtained in isolations from the gall might give different agglutination reactions. Bialosuknia and Klott (2), Stevens (29), Wright (31) and others have shown that one leguminous plant may harbor organisms possessing different serological properties. The crown gall organisms might be in the same category, in that the raspberry gall might harbor its own strain or the chrysanthemum strain or both.

It is also brought out in the serum agglutination tests that the strains shown to be identical by means of chemical agglutination tests are not necessarily identical when tested serologically. Had reliance been placed only upon chemical agglutination, no differences between the non-pathogenic organisms and the strains of *Ps. tumefaciens* could have been demonstrated. The results of the present investigations support the work of Jensen (10) and further show that the organisms may be similar morphologically and culturally, but different serologically.

The data also indicate that positive agglutination does not always mean that the strains or cultures are pathogenic, and at the same time a negative outcome does not necessarily mean that the cultures are non-pathogenic. This fact is brought out from the data presented in tables 8, 9 and 10. The results indicate that the identification of a culture should not be based upon agglutination tests alone, but susceptible hosts should be inoculated to verify pathogenicity of doubtful cultures.

It was brought out in the data presented in tables 8, 9 and 10 that the immune serum produced against *Ps. tumefaciens* (raspberry strain) failed to agglutinate the strains of the organism obtained from other hosts, namely, apple and rose. Further trials were, therefore, made to find out if this reaction of the serum would be maintained against other strains of

the pathogen obtained from hosts such as peach, (Prunus persica Sieb. and Zuce.), Prunus sp., geranium (Pelargonium hortorum Bailey), apple (Pyrus malus L.), walnut (Juglans nigra L.), incense cedar (Libocedrus decurrens Torr.) and rose (Rosa odorata Sweet). It was also shown by means of chemical agglutination tests (tables 5, 6 and 7) that all the strains of Pseudomonas tumefaciens and the 15 non-pathogenic organisms were identical in their reactions. Agglutination tests were, therefore, made upon 15 pathogenic strains against an immune serum produced with the pathogenic raspberry strain (R). The results of this trial are given in table 10. It will be seen from this table that the immune serum of Ps. tumefaciens (Raspberry) failed to agglutinate all other strains of the crown gall pathogen, thus showing again that the crown gall bacteria exhibit strain specificity and that the identification of the organism by means of serological agglutination tests might give erroneous results.

It is also brought out in this table that the passing of the raspberry pathogen (culture 1224) through a willow (Salix babylonica L.) in this case did not materially change the agglutinating capacity of the culture. Whether more passages through this host or some other host would have brought about a more decided change in the agglutinability of the organism, or whether such changes occur in nature are not definitely known at present and need further studies.

MAINTENANCE OF STRAIN SPECIFICITY

The results of the serological tests presented in tables 8, 9 and 10 indicated that the strains of *Pseudomonas tumefaciens* showed specificity, and that this could not be relied upon as a means of identifying the causal organisms obtained from various hosts. The question arose as to whether or not the passage through a susceptible host would bring about any changes in the original specificity of serological reaction. Since the strains of *Ps. tumefaciens* exhibited specificity and since they were pathogenic on tomato plants, attempts were made to find if the passage of the various strains through this host would bring about any closer relations in serological response.

Tomato plants were therefore inoculated with 11 strains of Ps. tume-faciens. The stock culture of Ps. tumefaciens (R strain) was also inoculated into tomato, Lycopersicon esculentum Mill., Bryophyllum calycinum Salish., and sugar beet, Beta vulgaris L. Isolations were made from the galls after 30 days from the day of inoculation and the colonies resembling the crown gall pathogen were streaked on agar slants. These colonies were inoculated into tomato plants to prove their pathogenicity. Such pathogenic strains reisolated from the galls on tomato plants, Bryophyllum calycinum and sugar beet, were used in agglutination tests against a rabbit immune serum produced from Pseudomonas tumefaciens (R strain). The technique employed in the serum agglutination tests was the same as previously described. The results of these trials are given in table 11.

It will be seen from the above table that all the strains except the original Ps. tumefaciens (R strain) failed to be agglutinated. This shows that a passage of these strains through a common host did not change the specificity of reaction of the organisms. At the same time, the original raspberry strain (R) when passed through tomato, Bryophyllum calycinum,

gall TABLE 10. Agglutination tests using Pseudomonas tumefaciens (strain R) antiscrum against 15 other strains of the crown organism.

Pathogen-	mato plants	+-	+-	+-	 	- -			- -	-4			-	+-	+-	+ •	+	
-		Raspberry	Peach	Apple	Geranium	Apple	: =		Feach Welmut	Waluut	Apple	Dunse The The	Kaspberry Willow	Prunus	Raspberry	Apple	Incense	Cedar
	Ck.	1	1	1	1	Į	1]	Quanta de la constanta de la c	ĺ	1		Warmen of the Control	l	Name of Street	1	l	
	1.25600		1		1			1		The same of the sa		Production			1		1	
	1-12800	H	1		1		I	1	1	1	l	1 '	pol	Marie and	1		1	
	1-6400	27	1		ļ	1	Management			1		1	c1	1	1]	1	
ion titre	1-3200	က	1	Marine	1	1	1		l		1	1	¢1	1	1		1	
Agglutination titre	1-1600	63	1	1	1	i	1		1	1	1	1	ಣ	1	1	1	1	
4	1-800	4	1	1	1	1	1	1		1		1	ಣ]	1	-	1	
	1-400	4				1	-	1	1	İ	1	1	ಣ	-			1	
	1-200	4	'	Į	-	1		1	1	1		1	4	1	1	!	-	
	1-100	4	'	1	1		1	-	-	1	1	1	4		-		1	
Chiltura	No.	P.	1071	1110	1212	1215	1216	1218	1219	1220	1221	1223	1224	1001	1000	1550	1000	Lino

*Culture 1224 was reisolated from a gall on weeping willow induced by artificial inoculation with culture B.

Effect on the agglutinability (using Ps. tumefaciens (R strain) antiserum) of 14 strains of Pseudomonas tumefaciens when passed through host plants other than the original. TABLE 11.

			1-25600		Distance of the last	I	1	1	fermone	1	-]		ļ		Į	1	ļ	. 1
			1-1280011				1	1		1	1	1				1	1	winners	_
			1.6400							1	1	- Company	1		G	3	က	ಣ	600
			1-1600 1-3200						1			1]]	cr	2	က	ಣ	60
	on titre		1-1600			-					-	1		-	/ ~	H -	4	00	4
)	Agglutination titre		1-800		1	1	-]	discount	- Sections	1	- Section 2	4	4 -	4	4	4
	Ā		1-400		į	l	ı			1	I	I	1	1	4		4	4	4
			1-200		Bernad	1	-			department of the second	1	-	- September	1	4		4	4	4
			1-100	-	1	1	1	manufacture			-	i	Î	-	4		d i	4	4
			CK.	1	1	1	ì	İ			1	1]	-	}		1	1	
	Pathogen icity of	reisolated	colony	+	+	+	+	+			<u>-</u>	+	+	+	+	_	 	+	+
		Pathogenic	no	Tomato	2	"	33	39	33	33	: :	. :		33	33	Daniel	-	Sugar beet	1
		Original	host	Peach	Geranium	Apple	20	33	Peach	Wolnut	Wainur ,	Apple	Prunus	Incense cedar	Raspherry	20	:	. :	"
	i	Culture	No.	1071	1212	1215	1216	1218	1219	1990	1001	1221	1225	1228	23	7	7 1	152	Ev3

and sugar beet plants was not altered in its agglutinability when tested against *Pseudomonas tumefaciens* (R strain) immune serum. It seems evident from these data that the strains of *Ps. tumefaciens* possess a definite specificity which was not changed by growth for 30 days within a susceptible host. The writer is not prepared to say whether or not these strains would exhibit any modification in specificity if allowed to grow in a common host for more than 30 days.

Goldsworthy (9) has recently shown that the sera produced against two morphologically and biochemically identical organisms causing gummosis of stone fruit trees were specific and that his Ps. cerasus No. 28 could not be cross-agglutinated by Ps. cerasus No. 29 and vice versa. This is in harmony with the writer's findings upon Ps. tumefaciens in that the organisms may be identical morphologically and yet show specificity in immune serum agglutination tests. Goldsworthy (9) notes that many of our plant pathogenic bacteria closely resemble each other, not only in disease manifestation, but in their morphological and biochemical character-Antisera might be used to advantage in identification. Such a means of identification would hasten the determination of pathogenicity over the old method, i. e. infection experiments. He states that "On the successful inoculation rests the fate of many isolated organisms. ful inoculations are rather rare in comparison with unsuccessful. The use of a highly potent antiserum should eliminate a great deal of the ineculation work and inconsistency in results." From the results (table 12) obtained with Ps. tumefaciens, it appears that infection experiments would be more reliable than serological agglutination tests (tables 8 and 9) in the identification of the organisms.

If Goldsworthy (9) had obtained only one immune serum, that for Ps. cerasus No. 28, he would have discarded all cultures of Ps. cerasus No. 29 as non-pathogenic. However, properly controlled inoculation experiments should lead to the correct determination of the pathogen. Otherwise, it would be necessary to prepare innumerable sera for the identification of the suspected organisms.

It is also shown in this paper (table 12) that the non-pathogenic cultures consistently gave negative results when inoculated into numerous hosts while the strains of $Ps.\ tumefaciens$ except in one case always produced infections. If the separation of these strains of $Ps.\ tumefaciens$ from the non-pathogenic organisms had been based entirely upon their agglutinability, a greater part of the pathogenic cultures would have been taken as non-pathogenic oragnisms and vice versa. Thus the results tend to show that the inoculation of suspected cultures furnishes a more reliable criterion of their pathogenicity than agglutination tests alone as now employed.

INFECTION EXPERIMENTS WITH STRAINS OF PS. TUMEFACIENS

Previous infection experiments had determined the fact that certain strains of Ps. tumefaciens were pathogenic while the 15 organisms resembling Ps. tumefaciens were non-pathogenic upon tomato plants. However, it seemed possible that by extending the host range, some plants might be found which would be infected by certain of these organisms previously considered non-pathogenic.

Since tomato plants are easily grown and are accessible at all times of the year, they were used in numerous inoculation trials. In addition, the host range was extended to include weeping willow (Salix babylonica L.), castor bean (Ricinus communis L.), alfalfa (Medicago sativa L.), life plant (Bryophyllum calycinum Salisb.), oleander (Nerium oleander L.), raspberry (Rubus occidentalis L.), apple (Pyrus malus L.), garden pea (Pisum sativum L.), and sweet pea (Lathyrus odoratus L.). Thus the results of the inoculation experiments on the above hosts may be considered indicative of the reaction of the 15 non-pathogenic organisms reported in this paper.

Using 24 to 48 hour cultures of the organisms grown on neutral potato dextrose agar, inoculations were made into the above mentioned hosts. The plants were placed three to five inches apart, kept in a moist chamber from four to six days and were watered individually for a few days after transferring to the greenhouse bench. This was done to avoid accidental infection by splashing of the organisms from one plant to another as shown by Riker and Keitt (24). Care was taken during the experiments to keep the plants in a vigorous growing condition. Numerous trials were made and in no case were the data recorded until after six weeks from the date of inoculations. The results of these trials are presented in table 12. The data presented in table 12 indicate that Pseudomonas tumefaciens (R strain) successfully produced galls in all cases on host plants belonging to 10 species in 10 genera. The exception was the culture number 1080. This culture had remained virulent for over two years when grown on neutral potato dextrose agar. However, the transfer of this culture made for general use, which we will designate as culture number 1080 N, was found to be non-pathogenic in February, 1927. Due to the possibility of this being caused by contamination, a fresh transfer from the stock culture (1080) was made February, 1927, and proved pathogenic on tomato plants. latter transfer was designated as number 1080-O. Culture number 1080-O lost its virulence in about three months (May 30, 1927). None of these cultures, numbers 1080, 1080-N and 1080-O, showed contamination in repeated dilution plate trials. They displayed a close resemblance in every respect to the other strains of Ps. tumefaciens. At the same time, the 15 non-pathogenic organisms vielded negative results on all the plants inoculated. Thus the results of these trials show that organisms which are alike morphologically, culturally and to a large extent serologically may differ markedly in their pathogenicity.

DISCUSSION

The results of the foregoing studies on strains of Ps. tumefaciens and certain non-pathogenic organisms closely resmbling the crown gall pathogen, show striking similarities between the two groups. The question arises as to the identity of the 15 non-pathogenic organisms isolated mainly from overgrowths at the union of piece-root grafted nursery apple trees. Such organisms appear to be intimately associated with overgrowths on nursery apple trees.

In their extensive isolation trials upon crown galls on various hosts, Smith, Brown and Townsend (28) also apparently found many organisms closely resembling *Ps. tumcfaciens* which, upon inoculation into susceptible

TABLE 12. Inoculation trials upon various hosts with 15 non-pathogenic organisms and two strains of Pseudomonas tumefaciens.

		Alfalfa	+	1	1	1	1	1	Ì	1	1	1	1	1	1	1	1	1	1
	Weeping	willow	+	1	1	1	1	1	-	1	1	1	1	ı	1	1	1	1	1
	Rasp-	berry	+	Į	i	1	!	1	1	ļ	1	1	Į	1	!	1	1	1	
	Bryo-	phyllum	+		1	1	-	1	!]	1	1	1	1	1	-	1	-	
Kind of hosts		Oleander	+	1	1	1	1	1	1	- Common - C	ì	1	1	1	1		1	1	1
Ki	Garden	peas	+	1	1	1	1	1	1	1	1	1	1	1	ı	1	1	1	1
	Sweet	peas	+	l	1	1	1	1	1	ļ	ļ	1	Į	!	1	i	1	I	1
	Apple	seedlings	+	1	1	1	1	1	1	I	1	1	1	1	1	1	1	1	1
	Castor	beans	+	1	1	1	1	l	1	1	1	1	I	1	ļ	1	1	1	1
	48 varieties	of tomatoes	+	-	1	1	1	1	-]	1		1	-	-		!	1	1	+1
	Culture	No.	**	15	27	33	43	50	86	116	119	121	123	130	133	139	162	174	1080*

*Strains of Ps tumefaciens.

plants, either failed to produce infection or induced only small, slow-growing atypical hyperlasias. In the early stages of their work, such organisms were regarded as forms other than the crown gall pathogen. Later, however, they formed the hypothesis that certain of these organisms were non-pathogenic strains of $Ps.\ tumefaciens$ which, due to their own by-products or those of the host tissue, had lost their virulence. Their hypothesis was based primarily upon the fact that certain virulent strains of $Ps.\ tumefaciens$ lost their pathogenicity after continued cultivation on artificial media. The writer has also reported a similar experience with one culture (1080). While loss of virulence is not infrequent when plant pathogens are grown on artificial media, there are no conclusive records of definite experiments leading to attenuation or enhancement of virulence, as is true of animal bacterial pathogens.

In a previous publication (18) the writer referred to certain bacterial organisms isolated from nursery soils as non-pathogenic strains of Ps. tumefaciens. These were also non-pathogenic upon young tomato plants. Subsequent cultural and morphological tests of such organisms showed a striking similarity to certain soil organisms, especially B. radiobacter. It should be noted, also, in this connection that the strain of B. radiobacter used could not in every case be separated by serological or chemical agglutination tests from either Ps. tumefaciens or certain of the 15 non-pathogenic organisms, resmbling the crown gall pathogen. It is, of course, common knowledge that B. radiobacter is a group species and, at present, poorly defined. Since these non-pathogenic organisms have so many characteristics in common with B. radiobacter and since these organisms in turn so closely resemble pathogenic strains of Ps. tumefaciens, it is not impossible that both Smith and the writer had B. radiobacter instead of non-pathogenic strains of Ps. tumefaciens.

The association of these non-pathogenic organisms with the overgrowths on the underground parts of the apple tree, their location in the convolutions of the overgrowth known to hold soil particles and their similarity in morphology, cultural and serological reactions, point to their close relationship with certain soil bacteria. Further biological studies may bring to light other characteristic reactions, which will serve to separate Ps. tumefaciens from non-pathogenic organisms of close similarity. criterion of pathogenicity of an organism is that it produce a specific disease, in this case, crown gall. The identity, therefore, of the causal organism freshly isolated from the gall is based upon its capacity to reproduce the original symptoms. Until some better means of differentiation are devised, it seems advisable to rely mainly upon the ability of the organism to produce galls as the chief mark of its identity as Ps. tumefaciens. In the light of our present knowledge, no characteristic of bacterial plant pathogens can be accorded greater species limiting importance than pathogenicity.

SUMMARY

Many non-pathogenic bacterial colonies closely resembling $Ps.\ tume$ faciens may be obtained in isolation trials on overgrowths at the union of piece-root grafted nursery apple trees. A critical study of 15 such non-pathogenic organisms showed that they are similar to $Ps.\ tume$ faciens morphologically as well as in cultural and chemical agglutination reactions. While slight differences in cultural reactions were noted, these were not sufficiently marked to separate the non-pathogenic organisms from $Ps.\ tume$ faciens. Thus cultures numbers 121, 123, 139 and 162 liquefied gelatin; cultures 43 and 33 showed slight pink coloration of plain milk, while cultures 121, 139 and 162 alone completely digested litmus milk in two weeks. In dextrin broth cultures 121, 123, 133 and 174 and in raffinose cultures 121, 123 and 174 produced alkalinity. In maltose only culture 121 produced alkalinity. In all cases the Voges-Proskauer and methyl red tests were negative.

Serological agglutination tests using antiserum from a non-pathogenic organism divided the entire group of organisms tested into two groups, those that did agglutinate and those that did not. In the first group are 9 non-pathogenic organisms, Bacillus radiobacter and two strains of Pseudomonas tumefaciens. In the second group are six non-pathogenic organisms, six strains of Ps. tumefaciens and Rh. leguminosarum. In a like manner, antiserum from a strain of Ps. tumefaciens separated the 15 non-pathogenic organisms and eight strains of Ps. tumefaciens, Rh. leguminosarum and B. radiobacter into two groups. Those that did agglutinate comprise 9 non-pathogenic oganisms, two strains of Ps. tumefaciens and B. radiobacter. Those that did not agglutinate include six non-pathogenic organisms, six strains of Ps. tumefaciens and Rh. leguminosarum, Agglutination tests using either of the two antiscra failed to separate the non-pathogenic organisms from the strains of Ps. tumefaciens. Serum produced with the raspberry strain of the crown gall organism did not agglutinate the strains isolated from apple, almond, walnut, geranium, incense cedar and rose. Serum produced by a non-pathogenic organism (culture 15) agglutinated only eight other non-pathogenic organisms, B. radiobacter and one strain of Ps. tumefaciens.

Passage of strains of Ps. tumefaciens through tomato plants did not

affect the agglutinability of the organisms.

Strains of Ps. tumefaciens consistently produced infection on plants of tomato (Lycopersicon esculentum Mill.), Bryophyllum calycinum Salisb., oleander (Nerium oleander L.), garden pea (Pisum sativum L.), sweet pea (Lathyrus odoratus L.), castor bean (Ricinus communis L.) and apple (Pyrus malus L.).

The strains of *Pseudomonas tumefaciens* were separated from the 15 non-pathogenic organisms studied only through their pathogenicity.

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THE FUNGI OF IOWA PARASITIC ON PLANTS

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The parasitic fungi, particularly those living on plants, have been the object of investigation in Iowa from the time when C. E. Bessey first established the Department of Botany at Iowa State College. This interest has almost become traditional with the succession of B. D. Halsted and L. H. Pammel to the chairmanship of that department. All three of these men had the study of parasitic fungi as one of their major interests, and the herbarium of the college has been the repository of their activities in this field. Added to their collections was a portion of the Holway herbarium. exclusive of the smuts and rusts, coupled with the collections of the Plant Disease Survey sponsored jointly by the Office of Mycology and Disease Survey of the Bureau of Plant Industry of the United States Department of Agriculture, and the Department of Botany of Iowa State College and carried out by the junior author. This survey, conducted in 1927, yielded approximately 1,200 specimens. The mass of these collections made an orderly arrangement of the fungi and their hosts seem very desirable, both from the standpoint of knowing what parasites occur in the State, and because of their potentialities as pests of the cultivated crops.

Geographically, the central position of Iowa in the United States has increased the value of the list, because, not only is the State in the transition area from forest to grassland, east and west, but it also lies across the line of change in a north and south distribution of vegetation. These circumstances give the list a range which would be difficult to duplicate on a similar area anywhere else in the United States, and make it useful not only in the area under consideration, but also to a large part of the adja-

cent territory.

The area under consideration has been covered by some of the most prominent collectors of parasitic fungi of the country. Among the names which are most often met in the herbarium, those of E. W. D. Holway, L. H. Pammel and J. C. Arthur are outstanding for the number and quality of their specimens. Others who have frequent contributions are C. E. Bessey, B. D. Halsted, F. C. Stewart, G. W. Carver, C. M. King, J. P. Anderson, A. S. Hitchcock, T. H. Macbride and G. W. Wilson.

A count of the listed fungi and diseases shows that there are 938 fungi and diseases on 1,019 host plants. Of these 916 are fungous parasites while 22 are maladies of non-parasitic origin. Of the parasites 195 are rusts, 61 are smuts, 46 members of the Peronosporales, 26 powdery mildews, 93 species of Septoria, 88 species of Cercospora, 36 species of Phyllosticta, 12 of Cylindrosporium, 24 of Ramularia, 19 of Fusarium, 31 bacteria. The

order showing the greatest number of species is the Moniliales with 197, the Uredinales being second with 195. The largest genus is Puccinia with 107 species represented. The distribution of these parasites is shown below:

DISTRIBUTION OF THE PARASITES AMONG THE FUNGI AS FOUND IN IOWA

ORDERS	FAMILIES	GENERA	No. of species in each genus
Plasmodiophorales [1]	Plasmodiophoraceae	Plasmodiophora	1
Eubacteriales [31]	Bacteriaceae	Bacterium Bacillus Pseudomonas	2 7 22
Actinomycetales [1]	Actinomycetaceae	Actinomyces	1
Chytridiales [8]	Olpidiaceae Synchytriaceae Cladochytriaceae	Olpidium Synchytrium Physoderma Urophlyctis	1 5 1
Saprolegniales [1]	Saprolegniaceae	Aphanomyces	1
Peronosporales [46]	Albuginaceae Pythiaceae Peronosporaceae	Albugo Phytophthora Basidiophora Bremia Peronospora Plasmopara Pseudoperonospora Sclerospora	5 2 1 1 28 7 1
Entomophthorales [2]	Entomophthoraceae	Empusa	2
Mucorales [3]	Mucoraceae Cephalidaceae	Sporodinia Rhizopus Syncephalis	1 1 1
Perisporiales [28]	Perisporiaceae Erysiphaceae	Parodiella Dimerosporium Erysiphe Microsphaera Phyllactinia Podosphaera Sphaerotheca Uncinula	1 5 5 1 2 5 8
Exoascales [8]	Exoascaceae	Exoaseus Taphrina	4 4
Myriangiales [1]	Plectodiscelleae	Plectodiscella	1
Pezizales [16]	Pezizaceae Caliciaceae Helotiaceae Mollisiaceae	Pezizella Vibrissea Selerotinia Fabraea Mollisia Pseudopeziza Pyrenopeziza	1 1 7 1 1 4

²Figures in brackets give number of species in each order.

ORDERS	FAMILIES	GENERA	No. of species in each genus
Phacidiales [10] ¹	Phacidiaceae	Coccomyces	5
TT . 1.1 P47	77 7	Rhytisma	5
Hysteriales [1]	Hypodermataceae	Lophodermium	1
Hemisphaeriales [1]	Microthyriaceae	Diplocarpon	1
Hypocreales [18]	Hypocreaceae	Hypocrea	1
		Hypomyces Scoleconectria	3 1
		Pleonectria	i
		Gibberella	3
		Balansia	ī
		Claviceps	3
		Cordyceps	4
		Epichloe	1
Dothideales [9]	Dothideaceae	Dothidella	1
		Phyllachora	6
		Plowrightia	2
Sphaeriales [46]	Sphaeriaceae	Acanthostigma	1
	Ceratostomaceae	Ceratostomella	1
	Mycosphaerellaceae	Sphaerella	1
		Guignardia	3 11
		Mycosphaerella Pleosphaerulina	1
	Pleosporaceae	Apiosporina	î
	2 1005F01400440	Didymellina	1
		Leptosphaeria	4
		Venturia	4
		Physalospora	2
	Managhana	Pyrenophora	1 1
	Massariaceae Gnomoniaceae	Massaria Glomerella	1
	Gnomoniaceae	Gnomonia	6
	Valsaceae	Diaporthe	ĭ
	Melanconidaceae	Cryptosporella	1
		Melanconis	1
	Melogrammataceae	Botryosphaeria	1
	77 1	Endothia	1
	Xylariaceae	Nummularia	1 1
		Hypoxylon	
Ustilaginales [61]	Ustilaginaceae	Cintractia	2 1
		Melanopsichium Schizonella	1
		Sorosporium	3
		Sphacelotheca	2
		Thecaphora	1
		Tolyposporium	1
		Ustilago	4
	Tilletiaceae	Doassansia	3
		Entyloma	13 1
		Neovossia Tilletia	4
		Urocystis	5

¹Figures in brackets give number of species in each order.

	. TO A WITE TIPE!	GENERA	No. of species in each
ORDERS	FAMILIES	OENERA	genus
Uredinales [195] ¹	Coleosporaceae	Coleosporium	4
		Cerotelium	1
		Cronartium	3
	Melampsoraceae	Hyalopsora	2
		Melampsora Pucciniastrum	8 4
	Pucciniaceae	Gymnoconia	1
	r ucciniaceae	Gymnosporangium	6
		Kunkelia	ĭ
		Phragmidium	10
		Puccinia	107
		Uromyces	38
		Uropyxis	2
	Imperfecti	Aecidium	7
		Uredinopsis	1
Agaricales [9]	Thelephoraceae	Corticium	1
Parameter Fr. 2	Exobasidiaceae	Exobasidium	2
		Microstroma	1
	Agaricaceae	Nyctalis	1
		Armillaria	1
		Pleurotus	1
	Polyporaceae	Fores	1
		Poria	11
Sphaeropsidales [179]	Sphaerioidaceae	Ascochyta	6
		Cicinnobolus	1
		Coniothyrium	4
		Cytospora	4
		Darluca Diplodia	1 1
		Fusicoccum	1
		Hendersonia	î
		Kellermania	ī
		Neottiospora	1
		Phleospora	2
		Rabenĥorstia	1
		Phoma	9
		Phomopsis	5
		Phyllosticta	36
		Plenodomus	1
		Septoria	93
	Leptostromataceae	Sphaeropsis Actinopelte	4 1
	Leptostromataceae	Discosia	1
		Gloeodes	1
		Melasmia	î
		Sacidium	ī
	Excipulaceae	Discella	1
		Dothichiza	1
Melanconiales [40]	Melanconiaceae	Colletotrichum	9
		Cylindrosporium	12
		Gloeosporium	9
		Hyaloceras	1
		Marssonina	5
		Melanconium	1
		Myxosporium	2
		Sphaceloma	1

²Figures in brackets give number of species in each order.

ORDERS	FAMILIES	GENERA	No. of species in each genus
Moniliales [197] ¹	Moniliaceae	Botrytis	4
Lary Lary		Cephalosporium	1
		Cercosporella	3
		Didymaria	1
		Ovularia	2
		Oidium	1
		Penicillium	2
		Piricularia	2
		Polyspora	1
		Ramularia	24
		Septocylindrium	1
		Verticillium	3
		Rhynchosporium	1
	Dematiaceae	Alternaria	8
		Basisporium	1
		Cercospora	88
		Cladosporium	9
		Dieoccum	1
		Helminthosporium	6
		Hadotrichum	1
		Heterosporium	1
		Fusicladium	1
		Gymnosporium	1
		Macrosporium	6
		Moniliochaetes	1
		Scolecotrichum	1
		Spondylocladium	1
	Stilbaceae	Graphium	1
	Tuberculariaceae	Exosporium	1
		Tubercularia	1
		Tuberculina	1
		Fusarium	19
		Sporotrichum	1
		Volutella	1
Mycelia sterilia [4]		Selerotium	2
		Rhizoctonia	2
Non-parasitic [22]		Virus	8
		Non-virus	14
		Total	938

¹Figures in brackets give number of species in each order.

Of the distribution on their host plants the greatest number are found upon the Gramineae with some 250 combinations of host and parasite. The Compositae ranked second with 157, while the Rosaceae were third with 137. These were followed by the Leguminosae, the Ranunculaceae, Solanaceae and Cruciferae with 89, 52, 46 and 35 combinations, respectively. The distribution of parasites on the various members of the plant families are tabulated below:

DISTRIBUTION OF THE PARASITES ON THE VARIOUS MEMBERS OF THE PLANT FAMILIES

SPERMATOPHYTA

1.	Gramineae	250	48.	Verbenaceae	5
2.	Compositae		49.	Araliaceae	4
3.	Rosaceae		50.	Menispermaceae	4
4.	Leguminosae		51.	Rutaceae	4
5.	Ranunculaceae		52.	Tiliaceae	4
6.	Solanaceae		53.	Amaranthaceae	3
7.	Cruciferae		54.	Apocynaceae	3
8.	Liliaceae		55.	Araceae	3
9.	Salicaceae		56.	Boraginaceae	3
10.	Urticaceae		57.	Campanulaceae	3
11.	Polygonaceae		58.	Ericaceae	3
12.	Labiatae		59.	Gentianaceae	3
13.	Caprifoliaceae		60.	Lobeliaceae	3
14.	Umbelliferae		61.	Oxalidaceae	3
15.	Cucurbitaceae		62.	Phrymaceae	3
16.	Cyperaceae		63.	Primulaceae	3
17.	Aceraceae		64.	Amaryllidaceae	2
18.	Betulaceae		65.	Bignoniaceae	2
19.	Pinaceae		66.	Crassulaceae	2
20.	Convolvulaceae		67.	Eleagnaceae	2
21.	Saxifragaceae		68.	Hypericaceae	2
22.	Chenopodiaceae		69.	Linaceae	2
23.	Scrophulariaceae		70.	Martyniaceae	2
24.	Fagaceae		71.	Nyctaginaceae	2
25.	Cenagraceae	12	72.	Nymphaceae	2
26.	Anacardiaceae		73.	Portulaceae	2
27.	Polemoniaceae		74.	Rhamnaceae	2
28.	Vitaceae		75.	Sapindaceae	2
29.	Iridaceae		76.	Santalaceae	2
30.	Rubiaceae		77.	Acanthaceae	ĩ
31.	Violaceae		78.	Calycanthaceae	î
32.	Asclepiadaceae		79.	Capparidaceae	î
33.	Euphorbiaceae	7	80.	Commelinaceae	î
34.	Oleaceae		81.	Cannaceae	ī
35.	Caryophyllaceae		82.	Dioscoreaceae	ī
36.	Celastraceae	_	83.	Fumariaceae	î
37.	Malvaceae	_	84.	Haloragidaceae	î
38.	Alismataceae		85.	Magnoliaceae	ī
39.	Hydrophyllaceae		86.	Orchidaceae	î
40.	Juglandaceae		87.	Papaveraceae	î
41.	Platanaceae		88.	Plumbaginaceae	î
42.	Balsaminaceae		89.	Polygalaceae	î
43.	Berberidaceae	7	90.	Phytolaccaceae	í
44.	Geraniaceae		91.	Resedaceae	î
45.	Cornaceae		92.	Staphyleaceae	1
46.	Juncaceae	_	93.	Sparganiaceae	1
47.	Plantaginaceae	-	94.	Thymelacaceae	1
210	I lambaginaceae	0	OI	In moracaccae	1

PTERIDOPHYTA

Equisetaceae	2	Polypodiaceae	4
E	UMYCI	ETES	
Agaricaceae Pucciniaceae Erysiphaceae Melampsoraceae Polyporaceae	4 3 2	Auriculariaceae Dothideaceae Elaphomycetaceae Mucoraceae Saprolegniaceae	1 1 1

MYXOMYCETES

Arcyriaceae 1 INSECTA—5

Of individual species, the cultivated apple harbors the most pests with some 26 species listed. Potato is second with 18 and wheat third with 17. Corn, barley and alfalfa have 16, 15 and 14, respectively, while oats and sweet potato have 13 parasites each. The American plum is next with 11 and the other hosts show 10 or less.

In collecting and working up the material gathered in this paper, the writers have enjoyed the help and cooperation of the members of the staffs of the Department of Botany of Iowa State College and the Office of Mycology and Disease Survey of the United States Department of Agriculture. Particularly, they wish to thank Mr. R. I. Cratty for his aid in the identification of host plants, Dr. S. M. Dietz for identification of the grasses, and Mrs. Florence Willey Nichols for her help in assembling the data and reading of proof. They also acknowledge the courtesy of the Department of Botany of the University of Minnesota for allowing them to examine the collections of Mr. E. W. D. Holway in the Holway Herbarium and especially wish to thank Mrs. Holway, who gave generously of her time and energy to make this examination pleasant and profitable.

A word of explanation will aid the reader to understand the form in which the material is arranged.

The fungi are arranged alphabetically, followed by their host plants in a similar arrangement. After each host are listed the localities in the State from which collections were seen. The specimens marked "Survey" were obtained during the plant disease survey conducted by the junior author in 1927. The cited literature has been gathered into a list at the conclusion of the paper, and the figures immediately following the accepted fungus name refer to a paper in which a description of the fungus may be found. The figures following the host name refer to papers citing the occurrence of the parasite on that host in Iowa. The specimens listed are to be found in the herbarium of the Department of Botany of Iowa State College, except those which are marked with an asterisk. One asterisk (*) is placed after those specimens from Iowa in the Holway Herbarium at the University of Minnesota, two asterisks (**) follow the Iowa specimens that were seen in the herbarium of the United States Department of Agriculture at Washington, D. C. No attempt has been made to list all the Iowa specimens in the two latter repositories. Only those not duplicated in the Iowa herbarium have been considered.

INDEX TO FUNGI

1. Acanthostigma occidentalis (E. & E.) Sacc. (123; 428, v. 9, p. 856) Syn. Venturia occidentalis Ell. & Ev.

On Artemisia ludoviciana Nutt. (123, 127). Ames: Halsted & Fairchild 1888 (Ell. & Ev. N. Amer. Fung. 2141)

On Cirsium altissimum (L.) Spreng. (127)

On Cirsium discolor Muhl. (127)

2. Actinomyces scabies (Thax.) Guess. (298)

On Beta vulgaris L. (356, 406)

On Raphanus sativus L. Ames: Melhus 1925.

On Solanum tuberosum L. (cult. potato) (8, 15, 191, 320, 370, 375, 383)

3. Actinopelte dryina (Sacc.) Höhn. (235, 494)

Syn. Actinopelte americana Höhn., Leptothyrium dryinum Sacc.

On Quercus ellipsoidalis Hill. Steamboat Rock: Anderson 1913.

On Quercus rubra L. Ames: Anderson 1913.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 732; Ell. & Ev. Fung. Col.

286; Thüm. Myc. univ. 1584.

Höhnel (235) has considered the American species, Actinopelte americana, distinct from the European form, Actinopelte dryina — Leptothyrium dryinum.

The specimens in Ell. & Ev. Fung. Col. 286 are said to be representa-

tive of the former and in Thüm. Myc. univ. 1584 of the latter.

After an examination of the cited exsiccati the present authors decide that the two species are not distinct and for this reason *Actinopelte americana* is reduced to synonomy.

Following is given a list of spore measurements:

Ell & Ev. N. Amer. Fung. 732—10-13.6 x 6.8-10 μ .

Ell. & Ev. Fung. Col. $286-10-13.5 \times 6.8-8.5\mu$.

Ell. & Ev. Fung. Col. 286—10-12 x 6-7μ. (cfr. Höhnel)

Iowa specimen—10-13.5 x 6.8-12 μ .

Thüm. Myc. univ. 1584— $10-13.6 \times 8.5-10 \mu$.

Thüm. Myc. univ. 1584—12-14 x 7-8μ. (cfr. Höhnel)

In the Iowa collection most of the spores were distinctly globose while in the Ell. & Ev. Fung. Col. 286 and Ell. & Ev. N. Amer. Fung. 732 they were ellipsoid. In Thüm. 1584 they varied from ellipsoid to globose. Presumably the spore shape is variable.

Aecidium alliicolum Wint, - Uromyces alliicolus.

Aecidium anemones Amer. auct. = Puccinia clematidis

Aecidium ari Amer. auct. — Uromyces caladii

Aecidium boltoniae Arth. = Puccinia asterum

Aecidium caladii (Schw.) Farl. - Uromyces caladii

4. Aecidium campanulastri Wils. (25, p.640) On Campanula americana L. (25, 31, 375, 522)

Aecidium cimicifugatum Schw. (25, p.333)
 Syn. Aecidium actaeae Authors. (Not Opiz.)

On Actaea alba (L.) Mill. (16, 253). Charles City: Arthur 1892.

Decorah: Holway 1881, 1881*, 1883**. Winneshiek Co.: Goddard 1895.

^{*}Specimens marked with an asterisk (*) were examined in the Holway Herbarium

at the University of Minnesota.

Specimens marked () were examined by W. A. Archer in the herbarium of the United States Department of Agriculture.

Sydow in Monographia Uredinearum I (484) includes this form under Puccinia actaeae agropuri Ed. Fisch., but with doubt as evidenced by the question mark after Actaea alba in his host list (p. 828), Johnson (253) has expressed the opinion that the form on this host was identical with that on Cimicifuga racemosa (L.) Nutt. Sydow (484) lists Aecidium cimicifugatum Schw. as a good species.

Arthur in his publications (25, 31) has reduced all these species to synonomy with Dicaeoma clematidis (DC.) Arth., but no cultural connections between the aecidium on Actaea and the grass hosts have been made in America; at least none was found to be reported. Jackson & Mains (247) report negative results with Puccinia triticina on Actaea. Kellerman (273) reports negative results with aeciospores from Actaea alba on Agropyron.

Arthur has reported this fungus from Iowa in both of his lists of Iowa Uredinales. Johnson reports its occurrence in Iowa in his paper. No exsiccati on Actaea alba were seen.

Aecidium compositarum Amer. auct.

On Helianthus strumosus L. - Puccinia helianthi-mollis

On Erigeron spp.

On Polymnia canadensis L. = Puccinia asterum

On Solidago latifolia L.

On Solidago rigida L.

On Prenanthes sp. = Puccinia orbicula

On Rudbeckia laciniata — Uromyces perigynius

On Senecio aureus — Puccinia eriophori

On Silphium perfoliatum = Uromyces silphii

Aecidium convallariae Schw. - Puccinia majanthae

Aecidium crassum Pers. = Puccinia coronata

Aecidium cuparissae DC. = Aecidium tithumali

Aecidium epilobii DC. = Uromyces plumbarius Aecidium erigeronatum Schw. = Puccinia asterum

Aecidium euphorbiae Schw. = Uromyces proeminens

Aecidium falcatae Arth. = Aecidium onobrychidis Aecidium fraxini Schw. = Puccinia fraxinata

Aecidium galii Pers. = Puccinia punctata

Aecidium geranii DC. = Puccinia polygoni-amphibii

Aecidium grossulariae DC. = Puccinia grossulariae

Aecidium hepaticatum Schw. = Puccinia pruni-spinosae

6. Aecidium hydnoideum Berk. & Curt. (25, p.631)

On Direa palustris L. (16, 25, 31, 253, 522). Decorah: Holway 1880, 1881, 1881*. *Pine Hollow*: Pammel and Trenk 1922.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1816.

Aecidium hydrophylli Pk, = Puccinia apocrypta

Aecidium hypericatum Schw. - Uromyces hyperici-frondosi

Accidium impatientatum Schw. - Puccinia impatientis

Aecidium iridis Ger. - Puccinia majanthae

Aecidium jamesianum Pk. - Puccinia jamesiana

Aecidium leguminosatum Lk. = Aecidium onobrychidis

Aecidium ludwigiae E. & E. = Puccinia jussiaeae

Aecidium menthae DC. = Puccinia menthae

Aecidium micropunctum E. & E. - Puccinia andropogi

Aecidium napaeae Arth. & Holw. - Puccinia hibisciata

Aecidium oenotherae Pk. = Puccinia peckii

7. Aecidium onobrychidis Burrill (25, p. 625-626)

On Amphicarpa monoica (L.) Ell. (Falcata comosa (L.) Kuntze) (16, 25, 31). Iowa: Holway (Ell. N. Amer. Fung. 1436), Ibid.*, 1881*.

On Apios tuberosa Moench (Glycine apios L.) (8, 16, 25, 31, 253).

Ames: Hitchcock 1885-86, Thomas 1879, Ibid.* Decatur Co.:
Anderson 1900.

Aecidium orobi DC.

On Trifolium repens L. = Uromyces trifolii-repentis

Aecidium oxalidis Thüm. — Puccinia sorghi

Aecidium penstemonis Schw. = Puccinia andropogi

Aecidium periclymeni Schum. - Puccinia periclymeni

Aecidium phlogis Pk. on Phlox divaricata = Puccinia plumbaria

Aecidium phlogis Pk. on Phlox pilosa = Uromyces polemonii

Aecidium phrymae Halst. = Puccinia phrymae

Aecidium pimpinellae Kirch, on Cicuta maculata L. = Uromyces scirpi

Aecidium podophylli Schw. = Puccinia podophylli

Aecidium polemonii Pk. — Uromyces polemonii

8. Aecidium polygalinum Pk. (25, p. 627)

On Polygala senega L. (16, 25, 31). Decorah: Holway 1880, 1882*, 1883**, 1883 (Rabenh. Wint. Fung. eur. 3319)*, 1882 (Ell. & Ev. N. Amer. Fungi 1009), Ibid.* 1899 (Syd. Ured. 1396)*

Aecidium porosum Pk, on Lathyrus venosus Muhl. = Uromyces fabae

Aecidium porosum Pk. on Psoralea argophylla = Uromyces argophyllae

Aecidium porosum Pk. on Vicia americana = Uromyces porosa

Aecidium punctatum Pers. = Puccinia pruni-spinosae

Aecidium pustulatum Curt. — Puccinia andropogi

Aecidium ranunculacearum DC. — Puccinia clematidis

Aecidium ranunculi Schw. — Puccinia eatoniae Aecidium sambuci Schw. — Puccinia sambuci

Aecidium tenue Schw. on Eupatorium perfoliatum and Eupatorium purpureum — Puccinia eleocharidis

Aecidium thalictri Grev. - Puccinia clematidis

9. Aecidium tithymali Arth. (25, p. 628-9)

On Euphorbia commutatus Engelm. (Tithymalus commutatus (Engelm.) Kl. & Garcke. (16, 25, 31). Decorah: Holway 1883*, 1885 (Barth, N. Amer, Ured. 703), Ibid*.

Aecidium urticae Schw. — Puccinia urticae

Aecidium verbenae Speg. = Puccinia verbenicola

Accidium violae Schum. = Puccinia ellisiana in part and Puccinia violae in part.

10. Aecidium xanthoxvli Peck. (25, p. 626-7; 397)

On Zanthoxylum americanum Mill. (16, 25, 31, 253, 397, 522). Decorah: Holway 1881, 1881*, 1886. (Ellis & Ev. N. Amer. Fung. 1013), Ibid.*, 1883 (Rabenh, Wint. Fung. eur. 2928)*, 1885 (Barth. N. Amer. Ured. 102), Ibid.* 11. Albugo bliti (Biv.) Kuntze (519)

On Acnida sp. Ogden: Archer 1927 (Survey 1207)

On Acnida tamariscina (Nutt.) Wood (299, 410)

On Acnida tuberculata Moq. (522)

On Amaranthus sp. (410)

- On Amaranthus blitoides Wats. (202, 299, 410). Ames: King 1911, Pammel 1910. Ogden: Archer 1927 (Survey 1208)
- On Amaranthus graecizans L. (299, 410, 522)

On Amaranthus hybridus L. (410, 519)

On Beta vulgaris L. (356, 361)

Raeder (410) reports this fungus on *Acnida cannabina* L. Since this host does not occur in Iowa, but a closely related species, *A. tuberculata* Moq., is frequently found, this report is referred to the latter host.

12. Albugo candida (Pers.) Rouss. (519)

- On Brassica arvensis L. (410). Ames: Ho 1923, Pammel 1911. Clarion: Melhus 1909.
- On Brassica nigra (L.) Koch. (299, 410, 521, 522). Ames: Bessey 1880.
- On Capsella bursa-pastoris L. (8, 54, 202, 299, 368, 380, 383, 410).

 Ames: Halsted 1885**; King 1912; Stewart & Pammel ——. Decatur Co.: Anderson 1904.

On Lepidium apetalum Willd. (8, 380, 410, 522)

On Lepidium draba L. Newton: Pammel and Latham 1926.

- On *Lepidium virginicum* L. (202, 289, 380, 410). *Winterset:* Pammel 1927 (Survey 1595)
- On Radicula armoracia (L.) Robinson (cult. horseradish) (8, 15, 406, 410). Ames: Pammel 1890, 1891. Decatur Co.: Anderson 1904.
- On Radicula palustris (L.) Moench. (Roripa palustris (L.) Bess.) (299, 410). Ames: Fawcett 1902, King 1902, 1914. Decatur Co.: Anderson 1904. Fayette: Wilson 1909 (Wilson & Seaver Ascom. Low. Fung. 76). Tripoli: Bennett 1912.

On Radicula sessiliflora (Nutt.) Greene (299, 410, 519) On Raphanus raphanistrum L. Turin: Pammel 1894.

- On Raphanus sativus L. (cult. radish) (8, 15, 368, 380, 383, 406, 410, 519). Ames: Pammel 1900, 1901, 1908; Stewart 1893. Council Bluffs: Pammel 1895. Decorah: Pammel 1908**. Waukon: Pammel 1908**.
- On Sisymbrium altissimum L. Ames: Gilman 1927 (Survey 660); Lennox 1925.
- On Sisymbrium canescens Nutt. (299, 410). Boxholm: Wilson 1927 (Survey 615)
- On Sisymbrium officinale L. (202, 299, 410). Decatur Co.: Anderson 1898. Glenwood: Archer 1927 (Survey 864)**. Grinnell: Conard 1921**. Indianola: Archer 1927 (Survey 1071)

13. Albugo ipomoeae-panduranae (Schw.) Sw. (482)

On Ipomoea batatas Lam. (208, 410). Ames: Pammel 1892.

On Ipomoea hederacea Jacq. Hamburg: Pammel and Clarke 1914.

14. Albugo portulação (DC.) Kuntze (519)

On Portulaca oleracea L. (8, 54, 202, 299, 368, 410, 519, 522). Ames: Bessey 1880; Hitchcock 1885-6; Raymond 1891. Conesville; Layton 1927 (Survey 1490)

15. Albugo tragopogonis (Pers.) Gray (519)

On Ambrosia artemisiifolia L. (202, 299, 410, 522). Ames: Layton 1927 (Survey 898). Radcliffe: Gilman 1924.

On Ambrosia psilostachya DC. (410, 519)

On Artemisia biennis Willd. (410, 483). Spirit Lake: Halsted 1885**.

On Cirsium arvense (L.) Scop. Rockwell City: Scott 1923. Winnebago Co.: Burns 1927 (Survey 817)

On Parthenium integrifolium L. (410, 519)

On Tragopogon porrifolius L. (cult. salsify) (406). Estherville: Burns 1926.

Allodus giliae (Pk.) Orton = Puccinia plumbaria

16. Alternaria spp.

On Acer saccharum Marsh. Grinnell: Conard 1923**.

On Capsicum frutescens var. grossum Bailey (cult. bell pepper) (15)

On Fagopyrum esculentum L. (cult, buckwheat), Charles City: Archer 1927 (Survey 1371)

Evidently this organism is not reported in the literature as the cause of a leaf spot. In one field, in 1927, leaf spotting was general.

On Sorbus americana Marsh. (cult. mountain ash). Shenandoah: Muncie & Archer 1926.

On Syringa spp. (cult. lilac). Shenandoah: Muncie & Archer 1926. 17. Alternaria brassicae (Berk.) Sacc. (514)

On Brassica nigra (L.) Koch (522)

On Brassica oleracea var. capitata L. (cult. cabbage) (406)

18. Alternaria crassa (Sacc.) Rands (412)

On Datura stramonium L. Mondamin: Archer & Muncie 1927 (Survey 1274)

On Datura tatula L. (522). Muscatine Co.: Gilman & Porter 1927 (Survey 1505)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1265b, 2485; Seymour & Earle, Ec. Fung. 339.

19. Alternaria forsythiae Harter (204)

On Forsythia sp. (cult.) (15). Shenandoah: Archer & Muncie 1926**. Muncie 1927 (Survey 1678)

20. Alternaria herculea (Ell. & Mart.) Elliott (119, 514, 515)

On Brassica nigra (L.) Koch. Boone: Archer 1927 (Survey 1195)

On Radicula armoracia (L.) Robinson (cult. horseradish) (15), Shenandoah: Bliss 1927 (Survey 1617)

Reported erroneously (15) as Alternaria brassicae.

21. Alternaria panax Whet. (516)

On Panax quinquefolium L. (cult. ginseng) (15, 406, 522)

22. Alternaria solani (Ell. & Mart.) Jones & Grout (413) On Lycopersicon esculentum Mill. (cult. tomato) (15)

On Solanum tuberosum L. (cult. potato) (8, 15, 191, 362, 375, 383). Fonda: Chapman 1912. Jefferson Co.: Whitaker 1909. Ledges-Boone: Coe 1912.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1265.

23. Alternaria tenuis Nees. (294)

On Lycium halimifolium Mill. Ames: Archer 1927 (Survey 1569) Exsic. cited: Ell. & Ev. Fung. Col. 1505.

Ampelomyces quisqualis Ces. = Cicinnobolus cesati

24. Aphanomyces raphani Kendrick (279)
On Raphanus sativus L. (cult. radish) (15)

25. Apiosporina collinsii (Schw.) Höhn. (433)

On Amelanchier canadensis (L.) Medic. (522). Decorah: Holway 1892. Aplanobacter insidiosum McC. = Bacterium insidiosum

Aplanobacter stewarti (EFS.) McC. = Bacterium stewarti

26. Apple scald (57)

On Pyrus malus L. (cult. apple) (407)

27. Armillaria mellea (Fr.) Quelet. (268)

On Paeonia sp. (cult.) Dumont: Archer & Gilman 1927 (Survey 1709) On Pyrus malus L. (15)

28. Ascochyta aquilegiae (Rabenh.) Höhn. (103, 221, 401, 488)

Syn. Depazea Aquilegiae Rabh., Phyllosticta Aquilegiae Roum. & Pat., Depazea (Psilosphaeria) Aquilegiae Rabh., Phyllosticta Aquilegiae (Rabh.) Bresad., Ascochyta Aquilegiae Sacc., Phyllosticta Aquilegicola Brun., Phyllosticta Aquilegiae Tehon & Daniels.

On Aquilegia spp. (cult. columbine). Osage: Archer 1927 (Survey 1402)

Exsic, cited: Krieger Fungi Sax, 1186 a and b.

The description and discussion of this fungus has been adequately handled by von Höhnel (221). However, von Höhnel's synonomy has been again listed in order to include the name made by Tehon and Daniels (488). Presumably these two authors overlooked the work of von Höhnel.

Diedicke (103), contrary to von Höhnel's findings, states that the example of Krieger Fungi Sax. 1186a in the Berlin Museum has only one-celled spores and was, therefore, a true Phyllosticta. At Ames there are two examples of this Krieger 1186a and in both the spores are distinctly septate. Quite likely the edition conferred by Diedicke merely happened to be a young stage.

29. Ascochyta imperfecta Pk. (89)

On Medicago sativa L. Conesville: Layton 1929.

30. Ascochyta oxybaphi Trel. (89).

On Oxybaphus nyctagineus (Michx.) Sweet (522)

Ascochyta pisi Lib. - Mycosphaerella pinodes

31. Ascochyta plumbaginicola P. Henn. (428, v. 18, p. 342)

On Limonium latifolium Kuntze (cult. sea lavender) (15). Shenandoah: Muncie & Archer 1926 (Survey 1635)

32. Ascochyta rhei Ell. & Ev. (89)

On Rheum rhaponticum L. (cult. rhubarb) (15). Shenandoah: Archer 1927 (Survey 1040)

33. Ascochyta violae Sacc. & Speg. (89)
On Viola pubescens Ait, (522)

34. Bacillus sp.

On Apium graveolens L. (cult. celery) (406)

35. Bacillus sp. (Slimy soft rot)
On Solanum tuberosum L. (cult. potato) (406)

36. Bacillus sp.

On Vigna sinensis Endl. (cult. cowpea) (406)

37. Bacillus amylovorus (Burr.) Trev. (425, 464)

On Crataegus monogyna Jacq. (cult. hawthorn) (15). Ames: Archer 1927 (Survey 666)

On Crataegus oxyacantha L. (cult. English hawthorn) (15). Shenandoah: Muncie & Archer 1926 (Survey 1637)

On Pyrus communis L. (cult. pear) (8, 15, 366, 368, 380, 383, 496). Ames: Rolfs 1891.

On Pyrus ioensis Bailey (366, 368, 380)

On Pyrus malus L. (cult. apple) (15, 83, 191, 366, 368, 376, 380, 383). Ames: Rolfs 1891, Ionia: Jacoby 1908.

On Purus prunifolia Willd. (366, 368, 380). Ames: Rolfs 1891.

On Purus serotina Rehd. (366, 380)

38. Bacillus atrosepticus van Hall (328)

On Solanum tuberosum L. (cult. potato) (15, 191, 376, 383, 406)

Bacillus campestris Pam. — Pseudomonas campestris

39. Bacillus carotovorus Jones (262)

On Allium cepa L. (cult. onion) (406)

On Brassica oleracea var. capitata L. (cult. cabbage) (15)

On Daucus carota L. (cult. carrot) (15, 406)

On Iris sp. (cult, iris) (15)

Bacillus delphinii EFS. = Pseudomonas delphinii

Bacillus phytophthorus App. = Bacillus atrosepticus

Bacillus solanacearum EFS. = Pseudomonas solanacearum

Bacillus sorghi Kellerm. - Pseudomonas andropogoni

40. Bacillus tracheiphilus EFS. (456)

On Cucumis melo L. (cult, cantaloupe) (15, 191, 406)

On Cucumis sativus L. (cult. cucumber) (8, 15, 191, 376, 406)

On Cucurbita maxima Duchesne (cult. squash) (15, 406)

Bacterium andropogoni EFS. = Pseudomonas andropogoni

Bacterium campestre (Pammel) EFS. = Pseudomonas campestris

Bacterium cannae Bryan = Pseudomonas cannae

Bacterium coronafaciens Elliott = Pseudomonas coronafaciens

Bacterium coronafaciens atropurpureum Reddy and Godkin - Pseudomonas coronafaciens atropurpurea

Bacterium delphinii (EFS.) Bryan = Pseudomonas delphinii

41. Bacterium insidiosum McC. (260)

Syn. Aplanobacter insidiosum.

On Medicago sativa L. (cult. alfalfa) (15, 406)

Bacterium lachrymans EFS. & M. K. Bryan = Pseudomonas lachrymans

Bacterium marginatum McC. = Pseudomonas marginata

Bacterium medicaginis (Sack.) EFS. = Pseudomonas medicaginis

Bacterium mori (B. & L.) EFS. = Pseudomonas mori

Bacterium phaseoli EFS. = Pseudomonas phaseoli

Bacterium phaseoli sojense Hedges = Pseudomonas phaseoli sojensis

Bacterium pruni EFS. = Pseudomonas pruni

Bacterium solanacearum EFS. = Pseudomonas solanacearum

42. Bacterium stewarti EFS. (457)

Syn. Aplanobacter stewarti EFS.

On Zea mays L. (field corn) (406)

On Zea mays var. rugosa Bonaf. (cult. sweet corn) (406, 411)

Bacterium striaefaciens Elliott = Pseudomonas striaefaciens

Bacterium translucens Jones et al. = Pseudomonas translucens

Bacterium translucens undulosum S.J. & R. — Pseudomonas translucens undulosa

Bacterium trifoliorum Jones et al. = Pseudomonas trifoliorum

Bacterium tumefaciens EFS. & Towns. = Pseudomonas tumefaciens

Bacterium vesicatorium Doidge = Pseudomonas vesicatoria

43. Balansia hypoxylon (Pk.) Atk. (41)

On Danthonia spicata (L.) Beauv. Boone: Buchanan 1909.

44. Basidiophora kellermanii (Ell. & Halst.) Wilson (520) On Iva xanthiifolia Nutt. Decorah: Holway 1888.

45. Basisporium gallarum Molliard (309)

Syn. Nigrospora oryzae (B. & Br.) Petch.

On Zea mays var. indentata Bailey (cult. corn) (10, 15, 113, 191, 406). Ames: Reddy 1927 (Survey 1711)

On Zea mays var. rugosa Bonaf. (cult. sweet corn) (15, 191, 406) From the evidence supplied by the careful investigation of Mason (309) there is no doubt but the name Nigrospora oryzae is the older name, but because of its common usage the authors have retained Basisporium gallarum.

46. Blast (sterility) (116)

On Avena sativa L. (oats) (15, 191)

47. Blossom end rot of tomato—non parasitic (56)

On Lycopersicon esculentum L. (cult. tomato) (15, 406)

48. Blossom end rot of watermelon—non-parasitic (344) On Citrullus vulgaris L. (cult. watermelon) (15, 406)

49. Botrytis spp.

On Allium cepa L. (cult. onion) (406)

On Narcissus sp. (cult.) (406)

50. Botrytis allii Munn (334, 507)

On Allium cepa L. (cult. onion). Pleasant Valley: Porter, D. R. 1927 (Survey 1706)

51. Botrytis cinerea Pers. (468, p. 579)

On Arisaema triphyllum L. Cedar Rapids: Archer 1927 (Survey 606)

Exsic. cited: Krieger Fung. Sax. 2084, 2294.

This fungus was found but once on a number of plants in the woods. The infected leaves were badly blighted and disintegrated.

On Brassica oleracea var. capitata L. (cabbage). Ames: Porter, D. R. 1926 (greenhouse)

On Geranium sp. (Madam Saleroi). Ames: Carver 1893.

On Lactuca sativa L. (15, 406). Council Bluffs: McPherson 1895.

52. Botrytis paeoniae Oud. (345)

On Paeonia sp. (cult.) Marshalltown: R. H. Porter 1929.

53. Botryosphaeria berengeriana deNot. (450) On Rhus glabra L. (189). Ames: Melhus 1924.

54. Bremia lactucae Regel (323)

On Lactuca sp. (54, 368, 383, 410)

On Lactuca canadensis L. (54, 166, 314, 522)

On Lactuca ludoviciana (Nutt.) Ridd. (166, 299, 314, 410) Ames: Bessey 1882, Hitchcock 1885-6.

On Lactuca sagittifolia Ell. (166, 314)

On Lactuca sativa L. (15, 166, 314, 376, 406). Nevada: Pammel 1913.

On Lactuca scariola L. var. integrata Gren. & Godr. (166, 314)

On Lactuca spicata (Lam.) Hitche. (202, 410). Spirit Lake: Halsted 1885**.

On Prenanthes alba L. (410)

 $Caeoma\ claytoniatum = Puccinia\ claytoniata$

Caeoma interstitialis Schlecht. = Kunkelia nitens

Caeoma luminatum Schw. = Kunkelia nitens

Caeoma nitens (Schw.) Burr. - Kunkelia nitens

Cenangium abietis (189) — Scoleconectria scolecospora

55. Cephalosporium acremonium Cda. (418) (Not *C. sacchari* as reported (406))

On Zea mays var. indentata Bailey (corn) (15, 406, 418)

56. Ceratostomella fimbriata (E. & H.) Elliott (120)

Syn. Sphaeronema fimbriatum E. & H.

On Ipomoea batatas Lam. (sweet potato) (15, 191, 202, 208, 406)

57. Cercospora sp.

On Cucurbita maxima Duch. (cult. squash) (406)

58. Cercospora alismatis Ell. & Holw. (124, p. 63) On Alisma plantago-aquatica L. (124, 522)

59. Cercospora althaeina Sacc. (124, p.38)

On Malva rotundifolia L. Mondamin: Archer 1927 (Survey 1270) Exsic. cited: Barth, Fung. Col. 4611; Seymour & Earle, Ec. Fungi. 266.

60. Cercospora ampelopsidis Peck (124, p. 55)

On Pscdera quinquefolia (L.) Greene (Ampelopsis quinquefolia L.) (522). Ames: Archer 1927 (Survey 1307); Halsted 1885**; Hitchcock 1885-86. Humboldt: Archer 1927 (Survey 1217)

On Psedera quinquefolia var. engelmanii Rehd. (Ampelopsis quinquefolia var. engelmanii). Shenandoah: Bliss 1927 (Survey 1631)

On Psedera quinquefolia var. hirsuta (Donn.) Rehd. (522)

On Psedera vitacea (Knerr) Greene (Ampelopsis vitacea). Steamboat Rock: Anderson 1913.

In the Iowa material the spores measure $30\text{-}103 \times 7\mu$. This is also true of the exsiccaticited. In other respects there is entire agreement with the original description.

Exsic. cited: Seymour & Earle Ec. Fungi 7; Winter Fung. eur. 3291.

61. Cercospora angulata Wint. (533)

On Ribes rubrum L. Ames: Blackwood 1903.

On Ribes vulgare Lam. (cult. currant) (8, 10, 15, 341, 342, 355, 357, 359, 362, 367, 368, 379, 380, 383). Shenandoah: Bliss 1927 (Survey 1168)

62. Cercospora anomala Ell. & Halst. (152)

On Actinomeris alternifolia (L.) DC. (Actinomeris squarrosa) (152, 199)

63. Cercospora antipus Ell. & Holw. (154)

On Lonicera flava Sims (124, 154). Decorah: Holway 1884 (type) On Lonicera sempervirens L. (scarlet runner honeysuckle) (15). Nora Springs: Archer 1927 (Survey 733)

On Lonicera sullivantii Gray (522)

64. Cercospora apii Fres. (124, p. 36)

On Apium graveolens L. (cult. celery) (15, 406). Ames: Raleigh 1927 (Survey 1481a)

65. Cercospora apii var. carotae Pass. (71)

On Daucus carota L. (cult. carrot) (15, 406). Cresco: Archer 1927 (Survey 1458). Elkader: Archer 1927 (Survey 1472)

66. Cercospora apii var. pastinacae Farl. (124, p. 36)

On Pastinaca sativa L. (8, 15, 124, 406). Ames: Carver 1892; Pammel 1911. Decatur Co.: Anderson 1905.

67. Cercospora apocyni E. & K. (124, p. 62) On Apocynum androsaemifolium L. (199)

68. Cercospora armoraciae Sacc. (435)

On Radicula armoracia (L.) Robinson (cult. horseradish) (15). Blockton: Campbell —. Muscatine Co.: Porter 1927 (Survey 1501)

69. Cercospora avicularis Wint. (533)

On Polygonum aviculare L. (8). Ames: Archer 1927 (Survey 1057). Conesville: Archer 1927 (Survey 943). Vail: Archer 1927 (Survey 1246)

On Polygonum erectum L. (199). Vail: Archer 1927 (Survey 1247)

On Polygonum ramosissimum Michx. Osceola: Gilman & Archer 1927 (Survey 886)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1772; Barth. Fung. Col. 2911.

70. Cercospora beticola Sacc. (124, p. 20)

On Beta vulgaris L. (cult. beet) (8, 15, 191, 368, 380, 383). Ames: Dwigans 1899; Hume 1899; Spaulding 1899**. Boone: Coe 1912. Decorah: Holway 1884.

On Beta vulgaris L. (cult. sugar beet) (15, 191, 380). Britt: Archer

1927 (Survey 1368)

On Beta vulgaris var. cicla Moq. (cult. Swiss chard) (15, 406). Marion: Archer 1927 (Survey 1478)

On Beta vulgaris var. macrorrhiza (cult. mangel) (10, 380)

Cercospora cana Sacc. - Cercosporella cana

71. Cercospora caricina Ell. & Dearn. (428, v. 14, pp. 1105-1106)

On Carex mirabilis Dewey. Indianola: Archer 1927 (Survey 1088) Exsic. cited: Ell. & Ev. N. Amer. Fung. 3489; Ell. & Ev. Fung. Col. 1170.

72. Cercospora catalpae Wint. (533)

On Catalpa spp. (cult. catalpa) (16, 406). Shenandoah: Muncie and Archer 1926 (Survey 1647)

On Catalpa speciosa Warder (199)

73. Cercospora caulophylli Pk. (124, p. 39)

On Caulophyllum thalictroides (L.) Michx. (522). Ames: Halsted 1885**. Decorah: Holway 1885.

Cercospora chenopodii Fres. = Cercospora dubia

74. Cercospora circumscissa Sacc. (4, 435)

On Prunus persica (L.) Stokes (cult. peach) (15, 199, 406)

On Prunus serotina Ehrh. (wild black cherry) (15). Delhi: Pammel 1924.

On Prunus virginiana L. (15). Rock Rapids: Pammel 1918.

Exsic. cited: Ell. & Ev. Fung. Col. 791, 386; Ell. & Ev. N. Amer. Fung. 646; Seymour & Earle, Ec. Fungi. 428a, 428b, 429.

75. Cercospora clavata (Ger.) Pk. (124, p. 54)

On Asclepias phytolaccoides Pursh. Decorah: Holway 1884**.

On Asclepias syriaca L. (522) (not Asclepias cornuti as reported (522).

Ames: Halsted 1885**. Boone: Archer 1927 (Survey 1180). Decatur Co.: Anderson 1897-1909. Decorah: Holway 1884.

Exsic. eited: Ell. & Ev. N. Amer. Fung. 823 a; Barth. Fung. Col. 2912; Seymour & Earle Ec. Fungi 327.

In the survey 1180 the spores measure $19-120 \times 3.4-6\mu$. The report of Cercospora syriaca L. (522) is evidently a misprint for C. clavata.

76. Cercospora concentrica Cke. & Ell. (78; 79; 428, v. 4, p. 479)

Syn. Čercospora yuccagena Cooke; Gloeosporium victoriense D. Sacc. On Yucca gloriosa L. Shenandoah: Bliss 1927 (Survey 1616)

Description:

Spots oval or irregular, 3×6 mm., scattered, sometimes confluent, brownish later with grayish centers, surrounded by dark brown margin. Grayish minute tufts appearing evenly scattered over grayish part of spot. In microscopic cross sections it is seen that the tufts arise from a dark compact hyphal mass below the cuticle. The conidia are quite irregular as to shape and size, but in general they are more or less cylindrical, sometimes crooked or slightly curved, $17\text{-}90 \times 3.4\text{-}7\mu$, 1-many septate, the septa often inconspicuous. The spores are greenish or with brownish tinge. The conidiophores are short $(20\text{-}40\mu)$, septate brownish, arising densely from the basal layer. In cross section of the fruiting structure the longer, cylindrical spores give a false impression of "basidia" or setae. Remarks:

The description of *Gloeosporium victoriense* D. Sacc. is close to the Iowa material, especially with reference to the described basidia which are said to be $90 \times 6.7\mu$, brownish and obscurely septate. These are doubtlessly nothing more than the long, projecting spores seen in Iowa material.

An examination of Cercospora yuccae Cooke in Ravenel Fungi Americani Exsiccati No. 292 indicates that the specimen is over-mature with no spores. This is true also of Carver's 579 collected in Alabama. However, in gross appearance the Iowa material corresponds to both these specimens. The original description in Saccardo (428 v. 4, p. 479) shows beyond doubt that the fungus of Cooke & Ellis is the same as that described by Saccardo. Furthermore, Cercospora floriicola Heald and Wolf probably belongs here. 77. Cercospora concors (Casp.) Sacc. (266)

On Solanum tuberosum L. (potato) (528). Fayette: Wilson 1924.

78. Cercospora davisii E. & E. (294)

On Melilotus alba Desr. (white sweet clover) (10, 15, 522, 530). Fayette: Wilson 1909 (Wilson & Seaver, Asco. & Lower F. 53). Humboldt: Archer 1927 (Survey 1212). Ledges—Boone: Anderson 1913.

On Melilotus officinalis (L.) Lam. (yellow sweet clover). Grundy Center: Archer 1927 (Survey 770).

The character of the spots on the leaves of *Melilotus officinalis* are identical with those caused by *Cercospora davisii* on *Melilotus alba*. Furthermore, the spore measurements coincide, $40-148 \times 3.5-5\mu$.

The fungus described under Cercospora meliloti Oud. (cfr. Lindau 294)) is distinct.

79. Cercospora depazeoides (Desm.) Sacc. (124, p. 34)

On Sambucus canadensis L. Ames: Halsted 1886 (Ell. & Ev. N. Amer. Fung. 1749b)

On Sambucus racemosa L. (10). Ames: Halsted 1886 (Ell. & Ev. N. Amer. Fung. 1749a)

80. Cercospora desmodii E. & K. (124, p. 50)

On Desmodium nudiflorum (L.) DC. Boone: Coe 1912.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1501; Ell. & Ev. Fung. Col. 1276.

81. Cercospora deutziae E. & E. (136)

On Deutzia gracilis Sieb. & Zucc. (15). Shenandoah: Bliss 1927 (Survey 1646)

82. Cercospora dioscoreae Ell. & Mart. (124, p. 54)

On Dioscorea villosa L. (522)

83. Cercospora dubia (Riess.) Wint. (294, 435)

On Atriplex patula L. Donnellson: Porter 1927 (Survey 1514)

Exsic. cited: Barth. Fung. Col. 4306; Krieger F. sax. 645, 1937, 896; Linhart Fungi hung. 499; Rabenh. Fungi europ. 2780.

According to Lindau (294), the spores should measure $50-70 \times 7.5-9\mu$. However, an examination of the specimens cited above indicates a variation of $34-70 \times 4-7\mu$.

On Chenopodium sp. Ames: Pammel 1892.

On Chenopodium album L. (199, 522). Ames: King 1910. Decorah: Holway 1884**. Ledges—Boone: Coe 1912. Vail: Archer 1927 (Survey 1242)

On Chenopodium album var. viride (L.) Moq. (522)

On Chenopodium hybridum L. Mondamin: Archer 1927 (Survey 1293)

Exsic. cited: Krieger F. sax. 897; Ell. & Ev. Fung. Col. 1087.

84. Cercospora echinocystidis E. & M. (124, p. 40) On Echinocystis lobata (Michx.) T. & G. (522)

85. Cercospora effusa B. & C. (124 p. 53) On *Lobelia siphilitica* L. (124, 199)

86. Cercospora euonymi Ell. (124, p. 19) On Evonymus atropurpureus Jacq. (8)

87. Cercospora fusimaculans Atk. (37)

On Echinochloa crusgalli (L.) Beauv. Mondamin: Archer 1927 (Survey 1294)

The spores in the Iowa material are somewhat larger than those described by Atkinson (37). The original description reads 25-40 x 2μ , while in the Iowa material, they are $20-81 \times 3.4-6.5\mu$.

88. Cercospora galii Ell. &. Holw. (154)

On Galium aparine L. (124, 154). Decorah: Holway 1884 (type)

89. Cercospora geranii Kellerm. & Sw. (277) On Geranium maculatum L. (522)

90. Cercospora granuliformis Ell. & Holw. (154, 435)

On Viola sp. (522). Boone: Coe 1912.

On Viola cucullata Ait. (124, 154). Decorah: Holway 1884 (type). Osage: Archer 1927 (Survey 1387)

On Viola obliqua Hill, Boone: Anderson 1913.

On Viola papilionacea Pursh. (8)

On Viola pubescens Ait. Anamosa: Pammel 1924.

Exsic. cited: Ell. & Ev. Fung. Col. 455.

In the figures given by Schwarze (435, p. 137, f. 809) the conidiophores are shown to be septate, although in the description (435, p. 136) they are said to be non-septate. The septa in the figures are evidently an oversight.

Examination of the specimens from Decatur Co., collected by J. P. Anderson (8) shows the one collected June 29, 1903, to be Marssonina violae (Pass.) P. Magn., while that collected July 8, 1905, was Phyllosticta violae Desm.

91. Cercospora gymnocladi E. & K. (124, p. 23) On Gymnocladus dioica (L.) Koch (199)

92. Cercospora helianthi E. & E. (134)

On Helianthus doronicoides Lam. (199) 93. Cercospora heucherae E. & M. (124, p. 34)

On Heuchera hispida Pursh. (522). Delhi: Pammel 1928. Grundy Center: Archer 1927 (Survey 791)

94. Cercospora hydropiperis (Thüm.) Speg. (272, 428 v. 4, p. 455)

Syn. Cercospora polygonorum Cke.

On Polygonum sp. Decorah: Holway 1884.

On Polygonum acre L. Ames: Hume and Hodson 1899.

On Polygonum hydropiper L. (522)

On Polygonum lapathifolium L. Boone: Archer 1927 (Survey 1181)

Exsic. cited: Barth. Fung. Col. 2311; Thüm. Myc. Univ. 1087.

95. Cercospora kellermanii Bub. (60)

On Althaea rosea Cav. (cult. hollyhock) (15) Osage: Archer 1927 (Survey 1388)

96. Cercospora lateritia Ell. & Halst. (152)

On Sambucus racemosa L. (S. pubens Michx.) (10, 152, 199). Ames: Halsted 1887 (Ell. & Ev. N. Amer. Fung. 1994) (type)

97. Cercospora leptosperma Pk. (124, p. 38)

On Aralia nudicaulis L. (124). Decorah: Holway 1884.

Davis (91) calls this fungus Septoriopsis leptosperma (Pk.) Davis. The writers follow the usage of Lieneman (291), who has left it in the genus Cercospora.

98. Cercospora lippiae Ell. & Ev. (134)

On Lippia lanceolata Michx. Clayton: Pammel 1923. Columbus Jct.: Pammel 1899.

Exsic. cited: Barth. Fung. Col. 3005.

99. Cercospora lycii Ell. & Halst. (152)

On Lycium barbarum L. Ames: Halsted & Fairchild 1889 (?) (Ell. & Ev. N. Amer. Fung. 2nd Ser. 2300)

On Lycium halimifolium Mill. (152, 199)

100. Cercospora macromaculans Heald and Wolf (210)

On Syringa spp. (purple flowered lilae) (15). Shenandoah: Bliss 1927 (Survey 1641)

101. Cercospora melanochaeta E. & E. (145)

On Celastrus scandens L. Ames: Archer 1927 (Survey 1565). Boone: Archer 1927 (Survey 1571)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 3595.

102. Cercospora menispermi Ell. & Holw. (136)

On Menispermum canadense L. (10, 136, 199, 522). Ledges—Boone: Pammel 1903; Coe 1912.

Exsic. cited: Ell. & Ev. Fung. Col. 596.

103. Cercospora microsora Sacc. (124, p. 35)

On Tilia sp. (hort. var.) (199). Nora Springs: Archer and Layton 1927 (Survey 735)

On Tilia americana L. Ledges—Boone: Anderson 1913; Archer 1927 (Survey 643). Cedar Rapids: Archer 1927 (Survey 607)

Exsic. cited: Seymour & Earle Ec. Fung. 104.

104. Cercospora monoica Ell. & Holw. (154)

On Amphicarpa monoica (L.) Ell. (8, 124, 154). Decorah: Holway 1884 (type)

105. Cercospora moricola Cooke (124, p. 34)

On Morus sp. (mulberry) (15). Conesville: Layton 1927 (Survey 1512)

On Morus alba L. Conesville: Layton 1928.

On Morus rubra L. (199)

106. Cercospora oculata È. & K. (124, p. 22) On Vernonia altissima Nutt. (522)

Wilson (522) reported this as Septoria oculata E. & K.

107. Cercospora olivacea (Berk. & Rav.) Ell. (124, p. 52)

On Gleditsia triacanthos L. (154). Decorah: Holway 1888**.

108. Cercospora omphakodes Ell. & Holw. (154)

On $Ph\hat{l}ox$ sp. (10)

On Phlox divaricata L. (124, 154). Decatur Co.: Anderson 1905.

Decorah: Holway 1884 (type)

On Phlox glaberrina L. var. suffructicosa Gray (Hort. var. Miss Lingard) (15). Shenandoah: Muncie and Archer 1926**; Bliss 1927 (Survey 1548)

The spores and conidiophores compare favorably with the type collection. However, the spots in the Survey 1548 have a dark brown color, while in the type they are yellowish. This may be due to the difference in the host; the Miss Lingard variety has thick leaves, while in the type they are thin

109. Cercospora opuli (Fckl.) Höhn, (91; 124, p. 63; 294)

Syn. C. penicillata var. opuli Fckl., C. varia Pk., C. penicillata Sacc., C. tinea Sacc., C. viburni Sacc.

On Viburnum lentago L. (10, 406, 522). Ames: King 1910.

On Viburnum opulus L. (cult. Eur. cranberry bush) (15) Shenandoah: Muncie & Archer 1926 (Survey 1640)

On Viburnum opulus var. sterile DC. ((cult. common snowball) (15). Shenandoah: Muncie & Archer 1926 (Survey 1638); Bliss 1927 (Survey 1639)

On Viburnum trilobum Marsh. (15). Shenandoah: Bliss 1927

(Survey 1315)

Exsic. eited: Thüm. Myc. univ. 668; Krieger F. sax. 943; Sydow Myc. mar. 991; Ell. & Ev. N. Amer. Fung. 3190; Clements Crypt. Colo. 280.

The Iowa collections show well-defined spots for the most part. The conidiophores may be epi- or hypophyllous or amphigenous. The spores vary from cylindrical to slightly clavate, $30\text{-}105 \times 3.4\text{-}6\mu$. In younger stages, 1-2 celled and approximating $30\text{-}60 \times 3.4\mu$, they are hyaline, but in mature stages, multiseptate and approximating $60\text{-}105 \times 4\text{-}6\mu$, they have a greenish caste.

A comparison of the Iowa material with the cited exsiccati and literature indicates a complete lack of distinction between the several species of

Cercospora reported on Viburnum.

Lindau (294) cites Krieger F. sax. 943 as an example of the species C. opuli, which he reports to have spores 40-60 x 5μ , yet an examination of two examples at Ames of this same exsiccati reveals spores measuring $59-103 \times 5\mu$, thus agreeing completely with those in Iowa material.

Likewise, Lindau (294) considers C. viburni Sacc. in Sydow Myc. mar. 2773, with spores 100×3.5 - 5μ to be the same as C. tinea Sacc., but the

latter is reported to have spores measuring $20-30 \times 3\mu$.

Furthermore, C. opuli (cfr. Lindau (294)) is supposedly distinguished by epiphyllous conidiophores, yet in Krieger F. sax. 943, cited by Lindau as typical, the spores are amphigenous.

Ellis & Everhart (124, p. 63) and Davis (91) evidently concede in the

view that C. varia differs but slightly from C. tinea.

In view of such a status, it is best to consider the several species under a single name, viz. C. opuli (Fckl.) Höhn.

110. Cercospora oxybaphi Ell. & Halst. (152)

On Oxybaphus nyctagineus (Michx.) Sweet (152, 199, 522). Beverly: Pammel 1905. Conesville: Layton 1927 (Survey 1496)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 3091; Ell. & Ev. Fung. Col.

393; Barth, Fung. Col. 3609.

In the original description of this fungus (Ellis and Halsted (152)), the spores are said to have a length of $30-50\mu$. However, in all the specimens cited the spores varied in length from $30-118\mu$.

Cercospora passaloroides Wint. = Cylindrosporium passaloroides

111. Cercospora physalidis Ell. (124, p. 19)

On Physalis sp. Ames: Pammel 1899, 1909. Boone: Coe 1912. On Physalis pubescens L. (199)

112. Cercospora polygonacea Ell. & Ev. (37, 124, p. 24)

On Polygonum convolvulus L. Conesville: Layton 1927 (Survey 1155)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1254; Seymour & Earle Ec. Fung. 365.

Cercospora polygonorum Cke. = Cercospora hydropiperis

113. Cercospora pteleae Wint. (533) On Ptelea trifoliata L. (199)

114. Cercospora pyri Farl. (124, p. 54)

On Pyrus malus L. (199)

115. Cercospora racemosa Ell. & Mart. (124, p. 55)

On Teucrium canadense L. (124, 199, 522). Ames: Carver 1892; Pammel 1890. Decorah: Holway 1884 (Ell. & Ev. N. Amer. Fung. 1504) 116. Cercospora racemosa Ell. & Mart. var. ambrosiae Seym. & Earle.

On Ambrosia trifida L. Ames: King 1910; Pammel 1910. Boone: Coe 1912.

Davis (87) reports Cercospora racemosa on Ambrosia trifida. Seymour and Earle on packet (Econ. Fung. 294a) give Cercospora ferruginea Auct. nee Fckl. as a synonym of Cercospora racemosa Ell. & Martin var. ambrosiae Seymour and Earle. "Conidiophores more rigid than in C. ferruginea Fckl. and much more frequently branched, cinnamon, not ferruginous. Differs from C. racemosa in longer and fewer branches as well as in host." These differences agree with Thüm. Myc. univ. 286, Krieger Fung. sax. 150 (2 examples), Syd. Myc. mar. 599 and Allescher and Schnabl. Fung. bav. 497.

117. Cercospora ranunculi Ell. & Holw. (124, p. 50)

On Rancunculus septentrionalis Poir. (not Ranunculus repens as re-

ported) (124, 154). Decorah: Holway 1884 (type)

The host was identified by Ellis and Holway (124, 154) as Ranunculus repens L., but the later investigations of Iowa plants indicate that R. septentrionalis is the proper species to which this host should be referred.

118. Cercospora resedae Fckl. (124, p. 21)

On Reseda odorata L. (380)

Cercospora reticulata Pk. = Cercosporella virgaureae (Thüm.) All.

119. Cercospora rhuina C. & E. (124, p. 33)

On Rhus glabra L. (8, 199). Boone: Coe 1912. Council Bluffs: Anderson 1912. Greenfield: Archer 1927 (Survey 1113)

Exsic. cited: Barth. Fung. Col. 2613.

The specimen reported by Anderson (8) as Cercospora rhuina C. & E. has been found to be Cylindrosporium toxicodendri (Curt.) E. & E.

120. Cercospora rosicola Pass. (124, p. 35; 428 v. 4, p. 460)

On Rosa sp. (15, 199). Ames: Carver 1892; Fogel 1902. Boone: Orton 1908**. Conesville: Archer 1927 (Survey 983). Shenan-doah: Muncie & Archer 1926**.

On Rosa blanda Ait. Ames: King 1909. On Rosa carolina L. Garner: Smith 1924.

On Rosa pratincola Greene (522). Boone: Coe 1912.

Exsic. cited: U. S. Dept. Agr. Div. Veg. Phys. & Path. 1127; Thüm. Myc. univ. 1086; Br. & Cav. Fung. Par. 45; Barth. Fung. Col. 3412; Allescher and Schnabl-Fung. Bav. 498 (on the label of which the following statement is made: "this fungus differs in that the conidiophores are hypophyllous and the spots are larger without the dark margin which characterizes the spots caused by Cercospora rosicola Pass."

Cercospora rudbeckiae Pk. = Cercospora tabacina 121. Cercospora sagittariae Ell. & Kellerm. (130)

On Sagittaria latifolia Willd. Ames: White 1898. Indianola: Archer 1927 (Survey 1083)

Exsic. eited: Ell. & Ev. Fung. Col. 693; Ell. & Ev. N. Amer. Fung. 2nd Ser. 1502.

122. Cercospora sedoides Ell. & Ev. (136)

On Penthorum sedoides L. (136, 199). Ames: Halsted & Hitchcock 1887 (Ell. & Ev. N. Amer. Fung. 1993)

123. Cercospora setariae Atk. (37)

On Setaria glauca (L.) Beauv. Ledges-Boone: Coe 1912.

124. Cercospora sii E. & E. (138)

On Sium cicutaefolium Schrank. (522)

125. Cercospora smilacis Thüm. (92, 294, 347)

On Smilax sp. Ames: King 1910.

On Smilax hispida Muhl. Muscatine Co.: Gilman & Layton (Survey 1494)

Exsic. cited: Ell. & Ev. Fung. Col. 390; Barth. Fung. Col. 2808; Thüm. Myc. univ. 1670, 1768; Seymour & Earle, Ec. Fung. 199.

126. Cercospora sordida Sacc. (124, p. 53)

On Tecoma radicans (L.) Juss. Ames: Halsted 1885**.

127. Cercospora spegazzinii Sacc. (428, v. 4, p. 475) On Celtis occidentalis L. (199)

128. Cercospora squalidula Peck. (124, p. 40; 395)

On Clematis virginiana L. (36, 102). Decorah: Holway 1884. (Rabenh. Wint. Fung. Europ. 3288; Ell. & Ev. N. Amer. Fung. 2nd Ser. 1522)

129. Cercospora stachydis E. & E. (148) On Stachys palustris L. (148)

130. Cercospora stomatica Ell. & Davis (146)

On Solidago latifolia L. Ledges—Boone: Archer 1927 (Survey 1573) Exsic. cited: Ell. & Ev. N. Amer. Fung. 3593; Ell. & Ev. Fung. Col. 1277; Davis Fung. Wis. 29.

131. Cercospora superflua Ell. & Holw. (130)

On Fraxinus sp. (10, 130, 199). Decorah: Holway 1885 (Ell. & Ev. N. Amer. Fung. 1525)

132. Cercospora symphoricarpi E. & E. (138)

On Symphoricarpos occidentalis Hook. Mondamin: Archer 1927 (Survey 1285)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 2976; Ell. & Ev. Fung. Col. 1086; Barth. Fung. Col. 4309, 4310, 4515.

133. Cercospora tabacina Ell. & Ev. (92, 136)

Syn. Cercospora rudbeckiae Pk.

On Brauneria purpurea (DC.) Britt. (Rudbeckia purpurea), (Echinacea purpurea) (cult. coneflower) (15). Shenandoah: Bliss 1927 (Survey 1645)

On Rudbeckia triloba L. (136, 199) Exsic. cited: Davis Fung. Wis. 80.

134. Cercospora teucrii Ell. & Kell. (124, p. 20; 156)

On Teucrium canadense L. (199). Ledges—Boone: Coe 1912. Mondamin: Archer 1927 (Survey 1278)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 2nd Ser. 1506.

135. Cercospora toxicodendri Ellis (124, p. 62) On Rhus toxicodendron L. (522)

136. Cercospora umbrata Ell. & Holw. (130)

On *Bidens* sp. (130). *Decorah*: Holway 1885 (Ell. & Ev. N. Amer. Fung. 1521)

On Bidens cernua L. Boone: Archer 1927 (Survey 1186)

On Bidens frondosa L. (199). Ames: Wright 1892.

On Bidens laevis (L.) BSP. (199)

Exsic. cited: Ell. & Ev. Fung. Col. 1088: Barth. Fung. Col. 3213. Cercospora varia Pk. - C. opuli

137. Cercospora variicolor Wint. (533)

On Paeonia sp. (199)

On Paeonia officinalis L. Ames: Carver 1892.

Exsic. cited: Barth. Fung. Col. 2709.

138. Cercospora venturioides Pk. (124, p. 20) On Asclepias suriaca L. (8)

139. Cercospora verbascicola Ell. & Ev. (136)

On Verbascum thansus L. Boone: Coe 1912.

140. Cercospora vernoniae E. & K. (124, p. 21)

On Vernonia baldwinii Torr, Indianola: Archer 1927 (Survey 1095)

On Vernonia fasciculata Michx. (8, 199)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 3090; Ell. & Ev. Fung. Col. 388: Barth. Fung. Col. 3310.

141. Cercospora viciae Ell. & Holw. (154)

On Vicia sativa L. (10, 124, 154). Chickasaw Co.: Holway 1884.

142. Cercospora violae Sacc. (124, p. 19) On Viola sp. (124, 406)

On Viola cucullata Ait. (15, 124). Dillon: Anderson 1913.

Exsic, cited: Krieger, Fung. sax, 1296; Seymour & Earle, Ec. Fung. 458a, 458b; Ell. & Ev. Fung. Col. 1520; Barth. Fung. Col. 2917. 3611.

143. Cercospora viticola (Ces.) Sacc. (428, v. 4, p. 458) On Vitis vinifera L. Boone: Coe 1912.

144. Cercospora zebrina Pass. (124, p. 39)

On Trifolium pratense L. (10, 522)

On Trifolium repens L. Marshalltown: Archer 1927 (Survey 1416) Exsic. cited: Krieger, F. sax. 1497; Thum, Myc. univ. 1272; Ell. & Ev. Fung. Col. 461: Barth, Fung. Col. 4709; Ell. & Ev. N. Amer. Fung. 2587; Davis, Fung. Wis. 145.

145. Cercosporella cana Sacc. (124, p. 54, 276, 294, 435)

On Erigeron sp. Decorah: Holway 1882.

On Erigeron annuus (L.) Pers. (522). Ames: Carver 1892. Fayette: Wilson 1909 (Wilson & Seaver Asco, & Lower Fungi 77)

On Erigeron canadensis L. (13, 36). Indianola: Archer 1927 (Sur-

vev 1091). Conesville: Archer 1927 (Survey 962).

Exsic, cited: Seymour & Earle Ec. Fungi 310, 312; Ell. & Ev. Fung. Col. 595; Barth. Fung. Col. 4009; Krieger, Fung. sax. 1297; Sydow Myc. mar. 795; Rabenhorst-Winter Fung. eur. 3290; Thüm, Myc. univ. 378, 378b.

146. Cercosporella chionea (Ell. & Kellerm.) Sacc. (124, p. 54; 428, v. 10,

p. 564)

On Cercis canadensis L. (8). Decatur Co.: Anderson 1904. Exsic. cited: Ell. & Ev. N. Amer. Fung. 2nd Ser. 1515.

147. Cercosporella virgaureae (Thüm.) All. (124, p. 61)

Syn. Cercospora virgaureae Thum., Ramularia virgaureae Thum., Cercospora virgaureae Oud., Septoria virgaureae Oud., Cercospora reticulata Pk., Cercosporella reticulata (Pk.) E. & E. (124, p. 61; 87, p. 888; 92, p. 261), Cercosporella nivea E. & B., (93, p. 170; 428, v. 14, p. 1066), Cercosporella ontariensis Sacc. (90, p. 675; 429, p. 551), Cercosporella dearnessii Bub. & Sacc. (91, p. 428), Ramularia tenuis Davis (92, p. 261)

On Solidago latifolia L. (199)

On Solidago serotina Ait. Menlo: Archer 1927 (Survey 1126)

Exsic. cited: Ramularia virgaureae—Ell. & Ev. N. Amer. Fung. 2291, 2465; Barth. Fung. Col. 2077, 3076, 3476; Kellerman & Swingle 18; Krieger F. sax. 445. Cercosporella nivea E. & B.—Barth. Fung. Col. 2711, 2507; Ell. & Ev. Fung. Col. 1165; Ell. & Ev. N. Amer. Fung. 3487. Cercosporella ontariensis Sacc.—Barth. Fung. Col. 4710.

A study of the exsiccati and the literature fails to maintain any distinction between the various species which are cited above in the synonomy. The variability of length and septation in the conidia is apparent and was fully recognized by Peck.

Further study of Cercosporella cana on Erigeron will probably result

in the combination of this form with that on Solidago.

148. Cerotelium dicentrae (Trel.) Mains & Anders. (25, p. 697)

On Dicentra cucullaria L. (Bicuculla cucullaria) (25, 31, 253, 303). Decorah: Holway 1886 (Barth. N. Amer. Ured. 203), Ibid.*; Holway 1887 (Syd. Ured. 497), 1888**. Morning Sun: Carver 1895.

149. Chlorosis

On Vitis labruscana Bailey (grape) (15)

Chrysomyxa pirolae (DC.) Rostr. = Melampsoropsis pyrolae

150. Cicinnobolus cesati DeB.

- On Erysiphe cichoracearum DC. on Ambrosia trifida integrifolia (Muhl.) T. & G. (7)
- On Erysiphe cichoracearum DC. on Artemisia ludoviciana Nutt. (380)

On Erysiphe cichoracearum DC. on Aster sp. (522)

On Erysiphe cichoracearum DC. on Aster cordifolius L. (7)

On Erysiphe cichoracearum DC. on Aster multiflorus Ait. (7). Decatur Co.: Anderson 1905.

On Erysiphe cichoracearum DC. on Aster salicifolius Lam. (7)

On Erysiphe cichoracearum DC. on Cirsium altissimum (L.) Spreng. (7)

On Erysiphe cichoracearum DC. on Cucumis sativus L. (7)

- On Erysiphe cichoracearum DC, on Helianthus tuberosus L. Ames: Rolfs 1891.
- On Erysiphe cichoracearum DC. on Hydrophyllum virginianum L. (7)
- On Erysiphe cichoracearum DC, on Lappula virginiana (L.) Greene (199)
- On Erysiphe cichoracearum DC, on Pilea pumila (L.) Gray (7)
- On Erysiphe cichoracearum DC. on Solidago canadensis L. (7) On Erysiphe cichoracearum DC. on Verbena stricta Vent. (522)
- On Erysiphe cichoracearum DC. on Verbena stricta Vent. (522) On Erysiphe cichoracearum DC. on Verbena urticifolia L. (7, 522)
- On Erysiphe cichoracearum DC. on Zinnia sp. Shenandoah: Archer 1926**.
- On Erysiphe polygoni DC. on Physalis heterophylla Nees. (7)

On Oidium sp. on Lactuca canadensis L. (7)

On Oidium sp. on Lactuca floridana (L.) Gaertner (7)

On Oidium sp. on Lactuca sagittifolius Ell. (7)

On Oidium sp. on Monarda mollis L. (7)

On Oidium sp. on Rosa sp. (7)

On Oidium sp. on Rudbeckia laciniata L. (7)

On Podosphaera oxyacanthae (DC.) DeBy. on Prunus americana Marsh, (522)

Cintractia avenae - Ustilago perennans

151. Cintractia caricis (Pers.) Magn. (74, p. 33)

On Carex pennsylvanica Lam. (15, 74, 245). Ames: Paddock 1893.

Iowa City: Hitchcock 1891**.

152. Cintractia junci (Schw.) Trel. (74, p. 34)

On Juncus tenuis Willd. (16, 53, 72, 74, 197, 245). Ames: Catlin 1923; Paddock 1893¹.

Cintractia reiliana (Kühn) Clint. — Sorosporium reilianum Cintractia sorahi (Link) Clint. — Sphacelotheca sorahi

Cintractia sphaerogena Burr. = Ustilago sphaerogena

153. Cladosporium sp.

On Avena sativa L. (oats) (406)

On Crataegus sp. (368)

On Setaria italica Beauv. (millet) (342, 406)

On Triticum vulgare Vill. (406)

154. Cladosporium aromaticum E. & E. (146)

On Rhus glabra L. Steamboat Rock: Anderson 1913.

Exsic. cited: Barth. Fung. Col. 3415.

155. Cladosporium astericola Davis (91, 92)

On Aster sagittifolius Wedem. Mondamin: Archer 1927 (Survey 1287)

Exsic. cited: Davis Fungi Wis. 127.

In the Survey 1287 the spots are much more extensive and distinct than in the type material. In fact, in some cases there is a distinct browning which extends along the veins over a considerable part of the leaf. In the type material the spores are $10-25 \times 3-5\mu$, while in the Iowa material they measure $10-20 \times 3.4-6\mu$.

156. Cladosporium carpophilum Thüm. (51)

On Crataegus mollis (T. & G.) Scheele (10, 368, 380)

On Prunus sp. (plum) (10, 341, 342, 406). Ames: Stewart 1893.

On Prunus americana Marsh. (10, 361, 363, 365, 368, 380, 383).

Ames: Pammel 1890**; Pammel 1893 (Seym. & Earle Econ. Fung. 422). Lake Mills: Pammel 1918.

On Prunus angustifolia L. (363)

On Prunus hortulana Bailey (363)

On Prunus persica (L.) Stokes. (cult. peach) (8, 15, 342, 383, 406)

On Prunus salicina Lindl. (Prunus triflora Roxb.). Ames: Craig

The Cladosporium on *Prunus cerasus* has been referred to *Venturia cerasi* by Bensaude and Keitt (51).

157. Cladosporium fulvum Cooke (435)

On Lycopersicon esculentum Mill. (cult. tomato) (15). Monticello: Melhus 1927 (Survey 1600)

^{&#}x27;Fide-G. P. Clinton.

158. Cladosporium graminum Cda. (251, 254, 297)

On Agropyron repens (L.) Beauv. Ames: King 1912.

On Avena sativa L. (352). Ames: King 1912.

On Bromus purgans L. Guthrie Center: Archer 1927 (Survey 1232); Humboldt: Archer 1927 (Survey 1215)

On Elymus robustus Scribn. & Sm. Muscatine: Archer 1927 (Survey 1025). Decatur Co.: Anderson 1900. Des Moines: Archer 1927 (Survey 1061)

On Elymus virginicus L. Shenandoah: Archer 1927 (Survey 845)

On Poa pratensis L. Ames: Chestik & Stewart 1894.

On Triticum vulgare Vill. (361, 383, 384, 389)

Exsic. cited: Thum. Myc. univ. 490.

159. Cladosporium herbarum (Pers.) Lk. (435)

On Avena sativa L. (389)

On Carex sp. Greenfield: Archer 1927 (Survey 1121)

On Equisetum arvense L. Des Moines: Archer 1927 (Survey 1060)

On Hordeum vulgare L. (361, 389, 406)

On Poa pratensis L. (389)

On Quercus alba L. Ames: Chestik & Stewart 1894.

On Zea mays L. Ames: Pammel 1909**.

Cladosporium herbarum on Poa pratensis L. (389) and Hordeum vulgare L. (361, 389, 406) is probably Cladosporium graminum Cda.

160. Cladosporium paeoniae Sacc. (428, v. 4, p. 362)

On Paeonia spp. (cult. peony) (15, 406)

On Paeonia officinalis L. Ames: Hill 1907. Center Point: Snyder 1896.

161. Cladosporium triostei Pk. (428, v. 4, p. 359)

On Triosteum perfoliatum I. (522). Decorah: Holway 1884.

Exsic, cited: Davis Fung. Wis. 134. Rabenh.-Wint.-Pazschke Fung. eur. 3995.

162. Claviceps sp. (36, 177)

On Zizania aquatica L. Forest City: Pammel 1908

163. Claviceps microcephala (Wallr.) Tul. (444)

On Calamagrostis canadensis (Michx.) Beauv. Ames: Archer 1927 Survey 1051); Smunt 1892.

On Phragmites communis Trin. Eagle Grove: Buchanan 1903. 164. Claviceps purpurea (Fr.) Tul. (444)

On Agropyron caninum (L.) Beauv. Lake Okoboji: Conard 1923**.

On Agropyron occidentale Scribn. Ames: — 1909. Dana: Elling 1912. Pomeroy: Hartley 1912.

On Agropyron repens (L.) Beauv. (15, 352, 376, 389, 406, 522). Ames: Anderson 1913. Belmond: Chapman 1912. Gilletts: Pammel 1912.

On Agropyron smithii Rydb. (352, 389, 406). Ames: Anderson 1913. Livermore: Henderson 1911. Ross: Shelev 1912.

On Agropyron tenerum Vasey. Eldora: Eggleston 1912.

On Agrostis alba L. (189)

On Avena sativa L. (10, 15, 406). Ames: Ball 1913**; Warburton 1909, 1913.

On Bromus inermis Leyss. (10, 406). Ames: Anderson 1913; Pam-

On Calamagrostis canadensis (Michx.) Beauv. (83, 352, 365)

On Elumus robustus Scribn, & Sm. (53, 375, 389). Ames: — 1908, 1909.

On Elumus striatus Willd. (352)

On Elumus virginicus L. (83, 352). Ames: Anderson 1913: Bessey 1876.

On Elymus canadensis L. Ames: Bettenga 1882.

On Gluceria fluitans (L.) R. Br. (352)

On Hordeum vulgare L. (hulless barley). Ames: _____ 1911.

On Hordeum vulgare L. (barley) (15, 191, 406). Akron: Dodge 1917**. Ames: Pammel 1914; Stewart 1893.

On Hystrix patula Moench. (352). Ames: Hume 1899. On Koeleria cristata Pers. Holstein: Porterfield 1915.

On Phleum pratense L. (53, 389). Ames: Bessey 1876. Postville: Roberts 1904.

On Poa pratensis L. (53, 406). Ames: Bessey 1878.

On Secale cereale L. (rye) (15, 53, 191, 352, 360, 375, 383, 389, 406). Ames: Bessey 1876; _____ 1909; King 1912, Grinnell: Conard 1920**. Rolfe: Whitmore 1912.

On Spartina michauxiana Hitche. (352)

On Triticum vulgare Vill. (wheat) (406). Ames: Bessey 1876; Warburton 1909.

165. Coccomyces sp.

On Prunus armeniaca L. (15, 351, 355). Shenandoah: Muncie and Archer 1926 (Survey 1621)

166. Coccomvces hiemalis Hig. (217, 270)

On Prunus sp. (cult. cherry) (15)

On Prunus avium L. (8, 12, 522). Decatur Co.: Anderson 1905.

On Prunus cerasus L. (cherry) (8, 191, 341, 351, 355, 357, 359, 361, 362, 368, 379, 380, 383, 406). Ames: Buchanan 1903; Morris Co.: Anderson 1900. Ledges-Boone: Anderson 1913. Lohrville: Middleton 1902. Mason City: Pammel 1908**. Muscatine Co.: Layton 1927 (Survey 1027)

On Prunus pennsylvanica L. Dillon: Pammel 1913.

On Prunus virginiana L. Waverly: Archer 1927 (Survey 1451)

167. Coccomvces kerriae Stewart (479)

On Kerria japonica DC. (cult.) Shenandoah: Muncie 1926**. 168. Coccomyces lutescens Hig. (217, 270)

On Prunus sp. (wild cherry). Osceola: Archer 1927 (Survey 1304)

On Prunus mahaleb L. (8, 355, 379). Ames: Carver 1892. Decatur Co.: Anderson 1902.

On Prunus serotina Ehrh. (355). Ames: Pammel 1908, 1913; Raymond 1891. Washington: Archer 1927 (Survey 988)

169. Coccomyces prunophorae Hig. (217)

On Prunus sp. (cult. plum) (15, 341, 406)

On Prunus americana L. (8, 341, 342, 379). Castana: Durr 1902. Decatur Co.: Anderson 1902.

On Prunus domestica L. (355, 379). Ames: Wright 1892.

On Prunus domestica L. (cult, German prune) (15), Shenandoah: Bliss 1927 (Survey 1622)

On Prunus domestica L. (Blue Damson plum). Muscatine Co.: Layton 1927 (Survey 1506)

The work of Keitt (270) would indicate the presence of more than one species or strain of Coccomyces on some hosts, but the differentiation seems to be somewhat involved. For the purposes of convenience the present authors will adopt the usage of the three species as proposed by Higgins (217).

170. Coleosporium carneum (Bosc.) Jackson (25, p. 89 and p. 653)

Syn. Coleosporium vernoniae B. & C.

On Vernonia sp. Decatur Co.: Anderson 1902.

- On Vernonia baldwinii Torr. (Vernonia interior Small) (25, 31). Avoca: Bartholomew 1921 (Barth. N. Amer. Ured. 2715)
- 171. Coleosporium solidaginis (Schw.) Thüm.(25, pp.90-92 and 655-657) On Aster, sp. (368, 410)
 - On Aster cordifolius L. (16, 25, 31, 53, 522). Ames: Bessey 1877; Hitchcock 1885-6.
 - On Aster drummondii Lindl. (16, 25, 31). Ames: Bessey 1882.

On Aster laevis L. (31)

- On Aster lateriflorus (L.) Britton (25, 31). Decatur Co.: Anderson 1904.
- On Aster multiflorus Ait. (25, 31)
- On Aster prenanthoides Muhl. Fraser: Pammel 1911.
- On Aster puniceus L. (25, 31, 522)
- On Aster sagittifolius Willd. (31)
- On Aster salicifolius Lam. (25, 31)
- On Callistephus chinensis Nees. (cult. China aster) (15, 16, 31, 53, 406). Ames: Bessey 1882; Halsted 1885**.

On Solidago altissima L. (25, 31)

- On Solidago canadensis L. (16, 25, 31, 53, 522). Ames: Arthur 1882; Ibid.*; Bessey 1878, 1882; King 1910; Morrison 1900. Spirit Lake: Arthur 1883*.
- On Solidago glaberrima Martens (25, 31)
- On Solidago latifolia L. (Solidago flexicaulis) (25, 31, 522)
- On Solidago nemoralis Ait. (16, 25, 31). Ames: Bessey 1882.
- On Solidago serotina Ehrh. (16, 25, 31, 53, 522). Ames: King 1910; Grinnell: Conard 1923**.
- On Solidago ulmifolia Muhl. Ames: Hitchcock 1885-6; Hume 1899; Pammel 1899.

Coleosporium sonchi-arvensis (Pers.) Wint, - Coleosporium solidaginis

172. Coleosporium terebinthinaceae (Schw.) Arth. (25, p. 93)

On Silphium laciniatum L. (16, 25)

Coleosporium vernoniae B. & C. = Coleosporium carneum

173. Coleosporium viburni Arth. (25, p. 88)

On Viburnum lentago L. (10, 16, 25, 31). Charles City: Arthur 1882** (part of type)

174. Colletotrichum circinans (Berk.) Vog. (506)

On Allium cepa L. (406, 506)

175. Colletotrichum erumpens Sacc. (469)

On Rheum rhaponticum L. (cult. rhubarb). Ames: Gilman 1928 (Survey 1721)

176. Colletotrichum graminicolum (Ces.) Wils. (524)

Syn. Colletotrichum cereale Manns

On Agrostis alba L. Maynard: Archer and Layton 1927 (Survey 751)

On Avena sativa L. (cult. oats) (15, 406)

On Bromus purgans L. Boone: Archer 1927 (Survey 1570)

On Hordeum vulgare L. (barley) (15, 191, 406)

On Panicum sp. (152, 199, 428, 524) On Secale cereale L. (rye) (15, 406)

On Triticum vulgare Vill. (wheat) (15, 191, 406)

177. Colletotrichum lagenarium (Pass.) Ell. & Halst. (180)

On Citrullus vulgaris L. (watermelon) (15, 191, 375, 406) On Cucumis melo L. (cult. cantaloupe) (15, 191, 316, 406)

On Cucumis sativus L. (cult. cucumber) (15, 191, 406). Davenport:
D. R. Porter 1924.

178. Colletotrichum lindemuthianum (Sacc. & Magn.) Bri. & Cav. (45)

On Phaseolus lunatus var. macrocarpus Benth. (Phaseolus limensis Macf.) (cult. lima bean) (8)

On Phaseolus vulgaris L. (cult. bean) (8, 15, 191, 384, 406). Ames: Pammel 1889. Sheldon: Beach 1908. West Union: Pammel 1908. Winona: Holzinger 1888.

179. Colletotrichum malvarum (Br. & Casp.) Southw. (98, 103, 465)

On Abutilon theophrasti Medic. Muscatine: Layton 1927 (Survey 1498)

On Althaea rosea Cav. (cult. hollyhock) (10). West Union: Pammel 1908.

The spores measured $13-23 \times 3.5-5\mu$, a few were 1-septate.

180. Colletotrichum silphii Davis (90)

On Silphium perfoliatum L. Ames: Gilman 1928 (Survey 1719). Ledges—Boone: Coe 1912.

181. Colletotrichum trifolii Bain (327)

On Medicago sativa L. (406). Algona: Odell 1914.

On Trifolium sp. (cult. clover) (406)

182. Colletotrichum violae-tricoloris R. E. Smith (463)

On Viola cucullata Ait. Ames: Gilman 1924.

In the Iowa specimen the spots were small, containing only a few acervuli. The setae were scattered.

183. Coniothyrium concentricum (Desm.) Sacc. (14)
On Yucca filamentosa L. Iowa: Pammel 1908**.

Coniothyrium fuckelii Sacc. = Leptosphaeria coniothyrium (Fckl.) Sacc.

184. Coniothyrium mixtum Fekl. (6) On Platanus occidentalis L. (9)

185. Coniothyrium pirinum (Sacc.) Sheld. (423)

On Pyrus communis L. (cult. pear) (15). St. Charles: Archer 1927 (Survey 1373)

On Pyrus malus L. (apple) (15). Elkader: Archer 1927 (Survey 1470). Osage: Archer 1927 (Survey 1395)

Exsic. cited: Bri. & Cav. Fung. par. 338.

This fungus is said to be a secondary invader of infected leaf tissue, but it occurs quite abundantly and frequently on living leaves.

186. Coniothyrium rosarum Cooke & Harkn. (503)

On Rosa sp. (cult.) (10, 503). Council Bluffs: Vogel 1917.

187. Cordyceps herculea (Schw.) Sacc. (444) On white grub (307)

188. Cordyceps militaris (L.) Link. (444) On white grub (444)

189. Cordyceps ophioglossoides Link. (444) On Elaphomyces variegatus Vitt. (307)

190. Cordyceps ravenelii Berk. (444) Syn. Torrubia ravenelii Berk. On white grub (444)

191. Corticium vagum B. & C. (66, 107, 114)

On Beta vulgaris L. (cult. beet) (341, 383, 406)

On Beta vulgaris L. (sugar beet). Ames: Pammel 1891.

On Capsella bursa-pastoris L. Ames: MacGregor 1929.

On Lactuca sativa L. (cult. lettuce) (406)

On Melilotus alba Desr. (white sweet clover). Ames: Gilman 1928.

On Melilotus officinalis (L.) Lam. (yellow sweet clover). Ames: Gilman 1928,

Coryneum juniperinum Ell. — Exosporium juniperinum Cronartium comandrae Pk. — Cronartium pyriforme

192. Cronartium pyriforme (Pk.) Hedge. & Long (25, p. 123 and p. 693) On Comandra pallida A.DC. (25, 31)

On Comandra umbellata (L.) Nutt. (25, 31, 522). Decorah: Holway 1884*.

193. Cronartium quercus (Brondeau) Schröt. (25, p. 122 and 691) On Quercus macrocarpa Michx. New Haven: Archer 1927 (Survey 1456), Oelwein: Archer 1927 (Survey 1437)

194. Cronartium ribicola Fisch. de Waldh. (25, p. 122 and 692) On Pinus flexilis James (406, 466)

On Pinus strobus L. (466)

195. Crown rot—Probably winter injury (259) On Medicago sativa L. (alfalfa) (15, 259)

196. Cryptosporella viticola Shear. (448)

On Vitis sp. (cult.). Logan: Nichols 1928.

197. Curly dwarf (343)

On Solanum tuberosum L. (potato) (15)

Cylindrosporium Grev. ...

The genus, Cylindrosporium, has been chosen as a vehicle for the species which follow, for convenient rather than taxonomic reasons because there are a number of genera, Septoria, Cylindrosporium, Phleospora, Septogloeum and sometimes Ascochyta and Glocosporium, each with numerous species which are scarcely separable on the basis of the present system of classification. (Cfr. Höhnel 232, p. 192; 228, p. 41; 226, p. 603-631; 231, p. 84-85; 237, p. 76; Laibach 288b, p. 172-174; Klebahn 286, p. 393). The species of these genera occurring on Fraxinus, Acer, Spiraca, Rhus, Pteris, etc., have a considerable range of variation in shape and size of spore, and in the presence or absence of a pycnidial wall and for this reason are being shifted constantly from genus to genus; (Cfr. Bubak 62, p. 28-30) thus has arisen a vast, confused tangle of names applied to vari-

ous developmental stages of a single fungus (Cfr. under Cylindrosporium

fraxini (E. & K.) E. & E. p. 333).

The polymorphism and variation of morphological characters in some of these fungi have been demonstrated recently: (1) Microconidia. Phyllosticta. Higgins (217 and 217a); Höhnel (226, p. 630; 232, p. 94-95); Klebahn (286, p. 55-60, p. 64). (2) Presence or absence of pycnidial wall. Archer (14, p. 15-17, p. 19, p. 48-49, Pl. I); Davis (92, p. 289-291); Klebahn (286, p. 128); Laibach (288b, p. 170, p. 173, p. 180); Stevens and Hall (470a, p. 47-51). (3) Spore size. Beach (49a, p. 28); Davis (88, p. 80-81; 92, p. 282); Dearness (95, p. 106); Stevens and Hall (470a, p. 61-70). (4) Disease characters. Beach (49a, p. 29); Laibach (288a, p. 210). Cylindrosporium acerinum Tr. and Earle — Septoria aceris

198. Cylindrosporium apocyni E. & E. (62, 90)

Syn. Septoria littorea Sacc., Septogloeum apocyni Peck, Glocosporium apocyni (Pk.) E. & E., Stagnospora apocyni (Pk.?) Davis, Dearnessia apocyni Bubak.

On Apocynum androsaemifolium L. Decorah: Holway 1884,

1885**.

The specimen (W. Va. Survey 3182) revealed a wide variation in the spore forms. They measured 25-90 x 3-7.5 μ . The fruit bodies were amphigenous, borne sometimes in small angular spots or again in larger areas as in *Dearnessia apocyni* or *Gloeosporium apocyni*. On older leaves the spots had the whitish centers characteristic for *Septoria littorea*.

Exsic. cited: Archer—W. Va. Survey 3182 (U. S. D. A. Herb.); Brenckle—Fungi Dakot. 472; Davis 1918—(U. S. D. A. Herb.); Dearness 1924—U. S. D. A. Herb.) (type)

199. Cylindrosporium aquilina (Pass.) comb. nov. (62a; 92; 98; 103, p. 353,

p. 498, p. 836; 137; 233; 428, v. 4, p. 31; v. 22, p. 1192)

Syn. Septoria aquilina Pass., Septogloeum septorioides Pass., Gloeosporium leptospermum Pk., Gloeosporium necans E. & E., Gloeosporium pteridis Harkn., Gloeosporium obtegans Sacc., Ascochyta pteridis Bres., Marssonia necans (E. & E.) Sacc., Fusidium pteridis Kalchbr., Gloeosporium pteridis (Kalchbr.) Kabat & Bubak, Marssonina necans (E. & E.) Magn., Ascochyta necans (E. & .E.) Davis, Cryptomycella pteridis (Kalchbr.) Höhn., Cryptomycella maxima Höhn.

On Pteridis aquilina L. Decorah: Holway 1883; Goddard 1899. Exsic. cited: Ell. & Ev. N. Amer. Fung. 2273, 2593; Griffiths, W. Amer. Fung. 324, 324a; Davis, Fung. Wis. 100; Krieger, Fung. sax. 989, 989b, 1363; Rabenhorst-Pazschke, Fung. eur. 4180, 4287 (Leg. Passerini!); Rabenhorst-Winter, Fung. eur. 2788 (Leg. Passerini!); Thüm. Myc. univ. 1395 (type collection, leg. Passerini!)

An examination of the exsiccati cited has shown that a single fungus is concerned. The spore size varies slightly, depending upon the condition of maturity of a particular pycnidium. In general, however, the spore measurements range between $20\text{-}30 \times 4\text{-}6\mu$ (cfr. Dearness (98)). The younger spores, of course, being shorter, i. e. $5\text{-}20\mu$. In those specimens labeled Glocosporium or Ascochyta, the majority of the spores were 1-celled, but 2-celled spores were common (cfr. Ellis & Everhart (137)); and 3 to 4-celled spores were not rare. In a number of the specimens there existed a microspore type $6\text{-}8 \times 3.5\mu$. In the exsiccati cited, those specimens

as Septogloeum or Septoria often had sterile pycnidia, but enough spores were present to determine that the fungus in hand was *Cylindrosporium pteridis*. Bubak (62a, p. 323) considers *Gloeosporium pteridis* (Kalehbr.) Bub. & Kabat to be distinct from *Gloeosporium necans* E. & E.

This fungus parallels closely the similar groups which occur on Acer p.

418, Fraxinus p. 333, and Spiraea p. 332.

Cylindrosporium californicum Earle = Cylindrosporium fraxini.

200. Cylindrosporium capsellae E. & E. (135)

On Capsella bursa-pastoris L. Ames: Gilman 1929.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 3183.

Cylindrosporium clematidis E. & E. — Septoria clematidis

201. Cylindrosporium eryngii E. & E. (159)

On Eryngium yuccifolium Michx. Greenfield: Archer 1927 (Survey 1111)

Exsic. cited: Ell. &. Ev. N. Amer. Fung. 2281.

202. Cylindrosporium filipendulae Thüm. (62, 90, 91, 93, 97, 98, 232)

On Spiraea sp. Ames: Stewart 1890-1894, Ibid.**

On Spiraca billardii Herineq. Shenandoah: Bliss 1927 (Survey 1644). Nora Springs: Archer 1927 (Survey 732)

On Spiraea douglasii Hook. (15). Shenandoah: Bliss 1927 (Survey 1642)

On Spiraea margarita Cy. (15). Shenandoah: Bliss 1927 (Survey 1643)

On Spiraea thunbergii Sieb. (15)

On Spiraea vanhouttei Zabel (15). Shenandoah: Bliss 1927 (Sur-

vey 1009)

Höhnel (232, p. 199), Bubak (62, p. 29-30), Davis (90, p. 673; 91, p. 427-429; 93, p. 157) have discussed possible synonomy of this fungus. Höhnel suggests that Cylindrosporium ariaefolium E. & E., Cercospora spiraeae Thüm. Cercospora rubigo Cooke & Hark, and Phleospora dolicho-

spora Sacc. might by synonyms.

In the Iowa collections the spore masses were epiphyllous usually and were pinkish to whitish in color. The spores were $40\text{-}75 \times 2.5\mu$, 1-2 septate, some clavate. On most of the hosts the fungus caused definite, brown, leaf spots, but in Survey 1643 (on *Spiraea margarita*) and Survey 1009 (on *S. vanhouttei*) they were inconspicuous. Macroscopically the last two specimens were not distinguishable from the type material of *Rhopalidium cercosporelloides* Dearn. (Cfr. Dearness (97, p. 170)).

The present authors consider that the fungus with elongated spores as described by Davis (91, p. 428) might not be distinct from either *Rhopalidium cercosporelloides* Dearn. or *Phleospora dearnessii* Bub. (Bubak, 62, p. 29). In fact, the fungi considered by the three authors are probably mere physiological variants of *Cylindrosporium filipendulae*.

203. Cylindrosporium fraxini (E. & K.) E. &. E. (92, 100, 226, 232, 286)
Syn. Asteroma fraxini DC., Dothidea fraxini Fr., Septoria fraxini Fr. Exosporium fraxini (Fr.) Niessl., Cercospora fraxini (DC.)
Sacc., Septoria fraxini Desm., Septoria fraxini Lasch., Septoglocum fraxini Harkn., Cercospora fraxini E. &. K., Cylindrosporium minor E. & K., Phyllosticta fraxini E. & M., Phyllosticta viridis E. & K., Piggotia fraxini B. & C., Septoria besseyi Pk., Septoria leucostoma E. & E., Marssonina fraxini Ell. & Davis, Cylindrosporium californicum Earle, Cylindrosporium fraxini

colum Dearn. & House, Cylindrosporium viridis E. & E., Septoria submaculata Winter, Phleosporina minor (Ell. & Kell.) Höhn., Glocosporium decipiens E. & E., Glocosporium fraxini Harku., Phlocochora fraxini (E. & K.) Höhn.

On Fraxinus sp. (10, 154, 393). Shenandoah: Bliss 1927 (Sur-

vey 1694)

On Fraxinus americana L. (15, 199). Mount Pleasant: Pannel 1917. Shenandoah: Bliss 1927 (Survey 910 and 1693); Bliss & Melhus 1927 (Survey 1691). Steamboat Rock: Pannel 1913.

On Fraxinus pennsylvanica var. lanceolata (Bork.) Sarg. (15, 199). Ames: Carver 1892; Hume 1899. Shenandoah: Bliss

1927 (Survey 1692)

To appreciate the synonomy which has been given above under Cylindrosporium fraxini, one has little more to do than merely compare macroscopically the various exsiccatic cited. A microscopic examination dispels the slightest doubt. The several so-called species so merge into one another as to be inseparable. Seemingly, the microspore stage (Phyllosticta—Piggotia) can occur separately, but often this form is mingled with the Cylindrosporium—Septoria, Gloeosporium—Marssonina stage. In the specimen (Survey 1693) both the minute, rod-shaped spores and the large Cylindrosporium spores occurred together in the same fruit body (cfr. Klebahn (286, p. 55-60, fig. 8 and 10); also Höhnel 226 and 232).

The epiphyllous occurrence of the fruit bodies has been the basis for distinguishing several of the "species", i. e. Cylindrosporium minor, Cylindrosporium californicum and Cylindrosporium fraxinicolum. However, when the exsicati of the first two species are examined the fruit bodies are found to be amphigenous. In the Iowa collections most of the spore masses were exuded on the lower surface of the leaf, although in one case (Survey)

1694) the spore heaps occurred on the upper surface.

Quite probably the position of the fruiting structure is determined by environmental factors, perhaps the moisture of the air, or the nature of the host leaf. Davis (92) has demonstrated the variation which may occur

in the fruit bodies on a single leaf.

Exsic. cited: Cercospora fraxini (DC.) Sace.—Bri. & Cav. F. par. 368; Septoria fraxini Fr.—Thüm. Myc. univ. 898; Septoria fraxini Desm.—Allescher & Schnabel, F. bar. 472; Septoria submaculata Winter-Ell. & Ev. N. Amer. Fung. 1614; Septoria frazini Lasch.—Ravenel, F. amer. 24; Exosporium fraxini Niessl.—Thüm, Myc. univ. 1978; Septogloeum fraxini Harkn.-Ell. & Ev. N. Amer. Fung. 1634; Cylindrosporium frazini Harkn.—Ell. & Ev. N. Amer. Fung. 1639; Ell. & Ev. Fung. Col. 1526; Barth. Fung. Col. 4719, 4816: Culindrosporium minor E. & K.—Ell. & Ev. N. Amer. Fung. 1900, 3470, Ell. & Ev. Fung. Col. 1159, Barth. Fung. Col. 4013; Phyllosticta fraxini E. & M.—Ell. & Ev. N. Amer. Fung. 1163; Phyllosticta viridis E. & K.—Ell. & Ev. N. Amer. Fung. 2834, Ell. & Ev. Fung. Col. 1138, Barth. Fung. Col. 2548; Piggotia fraxini B. & C.—Ell. & Ev. N. Amer. Fung. 743, Barth. Fung. Col. 2852, 1261, 2254, 3048, 4248, Seymour & Earle, Ec. Fungi 141, Ex. herbarium U.S.D.A.

5043, Kellerman, Ohio Fungi 24, Griffiths, West. Amer. Fungi 197, 197a; Septoria leucostoma E. & E.—Ell. & Ev. N. Amer. Fung. 2852; Marssonina fraxini E. & Davis—Davis, F. Wis. 68; Gloeosporium decipiens E. & E.—Ell. & Ev. N. Amer. Fung. 2269, Kellerman & Swingle, Kansas Fungi 9.

204. Cylindrosporium humuli E. & E. (134)

On Humulus lupulus L. (10, 522). Ledges—Boone: Coe 1912. Exsic. cited: Ell. & Ev. N. Amer. Fung. 3384; Ell. & Ev. Fung. Col. 858; Seymour & Earle, Ec. Fungi 496.

205. Cylindrosporium iridis E. & Halst. (153)

On Iris sp. (10, 152, 428)

On Iris versicolor L. (153, 199)

Cylindrosporium minor E. & K. = Cylindrosporium fraxini

Cylindrosporium negundinis E. & E. — Septoria aceris

206. Cylindrosporium passaloroides (Wint.) comb. nov. (532)

Syn. Cercospora passaloroides Wint.

On Amorpha fruticosa L. Shenandoah: Bliss 1927 (Survey 1615)
This fungus was found to be abundant on nursery plantings of
Amorpha fruticosa at Shenandoah, where it caused a 30 per cent leaf infection, accompanied by a decided yellowing.

Hand sections through infected leaves revealed that the spores are borne in an acervulus below the epidermis. Evidently Winter (532) placed this fungus in the genus Cercospora on the mere basis of spore shape. (See text fig. 1.)

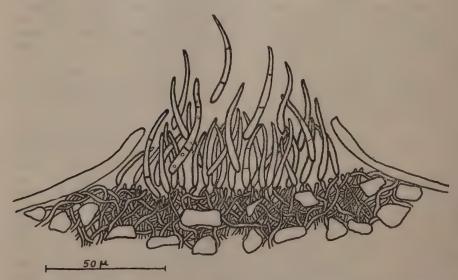


Fig. 1. Cylindrosporium passaloroides (Wint.) nov. comb. on Amorpha fruticosa L.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1999; Barth. Fung. Col. 3512; Carver Ala. 65.

Cylindrosporium pennsylvanicum E. & E. — Septoria aceris Cylindrosporium platanoides (All.) Died. — Septoria aceris Cylindrosporium saccharinum E. & E. — Septoria aceris

207. Cylindrosporium saccharinum E. & E. = Septoria ace

On Salix sp. (15). Boone: Archer 1927 (Survey 1191). Emmetsburg: Archer 1927 (Survey 1342). Fayette Co.: Archer & Layton (Survey 744)

On Salix sp. (cult, weeping willow) (15)

On Salix pentandra L. (cult. laurel leaf willow) (15). Shenandoah: Bliss 1927 (Survey 1523)

On Salix vitellina L. (cult. golden willow) (15)

208. Cylindrosporium toxicodendri (Curtis) E. & E. (62, 92, 95, 144, 394)
Syn. Gloeosporium toxicodendri E. & M., Marssonia toxicodendri (E. & M.) Magn. Septoria irregularis Pk. Septoria rhoidis B. & C. Septoria rhoina Sacc., Septoria toxicodendri Curt., Septoria toxicodendri (Curt.) E. & M.

On Rhus glabra L. (502). Germania: Melhus & Durrell 1924. On Rhus hirta var. dissecta Rehd. (cult. cut leaf sumac) (15). Shenandoah: Bliss 1927 (Survey 1662)

On Rhus toxicodendron L. (129, 143, 144, 199, 502, 522).Ledges— Boone: Coe 1912.

On Rhus typhina L. (10). Decorah: Holway 1888**. Muscatine: Pammel 1899.

Exsic. cited: Kabat & Bubak Fungi imperfecti 284; Brenckle—Fungi Dakotenses 273; Nash—Plants of Florida 1935; Ell. & Ev.—Fung. Col. 447, 679, 1350; Barth. Fung. Col. 2635, 4429, 4430,4734; Ell. & Ev.—N. Amer. Fung. 1127, 1898, 2447a, 2447b, 2956; Kellerman—Ohio fungi 157, Flora Kansas 662. Griffiths—W. Amer. Fungi 344; U. S. D. A.—Herb. 215, 1781.

209. Cylindrosporium tradescantiae E. & K. (158)

On Tradescantia bracteata Small. Grundy Center: Archer 1927 (Survey 784)

Exsic. cited: Barth. Fung. Col. 2220. Cystopus bliti (Biv.) Lev. — Albugo bliti

Cystopus candidus (Pers.) Lev. — Albugo candida

Cystopus cubicus Lev. = Albugo tragopogonis

Cystopus ipomoeae-panduranae (Schw.) Stev. & Sw. = Albugo ipomoeaepanduranae

Cystopus portulacae (DC.) Lev. = Albugo portulacae

Cystopus tragopogonis (Pers.) Schröt. = Albugo tragopogonis

210. Cytospora chrysosperma (Pers.) Fr. (296)

On Populus spp. (cult. poplar) (15, 406). Des Moines: Gilman 1926. On Populus balsamifera var. suaveolens (Fisch.) Wesm. (Chinese white poplar). Ames: Dorsett 1911**.

On Populus alba L. var. pyramidalis Bunge. (Populus bolleana Carr.).

Griswold: Gilman 1926.

On Populus deltoides Marsh. Ames: Gilman 1926.

On Salix babylonica L. (Salix blanda Anders.) (weeping willow).

Ames: Melhus 1926.

This fungus was a common follower after winter injury.

211. Cytospora platani Fekl. (428, v. 3, p. 267)

On Platanus occidentalis L. Ames: Anderson 1913.

212. Cytospora rubescens Fr. (428, v. 3, p. 253)

On Sorbus aucuparia L. (European mountain ash) (15). Shenandoah: Archer 1927 (Survey 1161)

Exsic. cited: Thüm. Myc. univ. 382.

213. Cytospora salicis (Cda.) Rabenh. (428, v. 3, p. 261)

On Salix purpurea L. (cult.). Burlington: Pammel 1914.

Exsic. cited: Thüm. Myc. univ. 1382.

214. Darluca filum (Biv.) Cast. (435)

On Melampsora bigelowii Thüm. on Salix interior Row. (S. fluvitalis Nutt.) (522)

On Melampsora humboltiana Speg. on Salix nigra Marsh. (8). Ames: Carver 1892. Decatur Co.: Anderson 1904

On Melampsora medusae Thüm, on Populus deltoides Marsh (522)

On Puccinia asparagi DC. on Asparagus officinalis L. (522). Ames: Pammel 1902. New Hampton: Archer 1927 (Survey 1453)

On Puccinia graminis Pers. on Poa pratensis L. (8). Decatur Co.: Anderson 1903.

On Puccinia graminis Pers. on Hordeum jubatum L. (8). Decatur Co.: Anderson 1904.

On Puccinia graminis Pers. on Phleum pratense L. (385)

On Uromyces silphii (Burr.) Arth. on Juneus interior Weig. (522)

Dearnessia apocyni Bub. — Cylindrosporium apocyni Diaporthe juglandis E. & E. — Melanconis juglandis

215. Diaporthe pruni Ell. & Ev. (513)

On Prunus sp. Decorah: Holway 1892.

On Prunus hortulana L. Ames: Miller 1924.

On Prunus serotina Ehrh. Decorah: Holway 1892.

216. Dicoccum populinum E. & E. (144) On Populus grandidentata Michx. (144)

Didymaria ungeri Cda. = Didymaria didyma (Ung.) Schröt.

217. Didymaria didyma (Ung.) Schröt. (128, 294)

Syn. Ramularia didyma Unger.

On Anemone canadensis L. Conesville: Arthur 1927 (Survey 973)

On Anemone cylindrica Gray (199)

On Anemone virginiana L. (128). Boone: Anderson 1913. Decorah: Holway 1884 (Ell. & Ev. N. Amer. Fung. 2nd Ser. 1529)

On Ranunculus pennsylvanicus L. (128) On Ranunculus recurvatus Poir. (522)

On Ranunculus septentrionalis Poir. (not Ranunculus repens as reported). Decorah: Holway 1885.

218. Didymellina iridis (Desm.) Höhn. (497)

Syn. Heterosporium gracile (Wallr.) Sacc., Scolecotrichum iridis Fautr. & Roum.

On Belamcanda chinensis DC. (199). Decorah: Holway 1884. On Iris spp. (cult. iris) (15). Ames: Lennox 1924; Towne 1924. Nora Springs: Archer 1927 (Survey 737)

On Iris germanica L. Grinnell: Conard 1923.

The specimen of *Scolecotrichum iridis* was collected from the same plants as the *Heterosporium gracile* specimens and in similar spots on the leaves. This fact confirms Saceardo's (428, v. 10, p. 600) opinion that this fungus is but an immature stage of *Heterosporium gracile*.

Dimerosporium collinsii (Schw.) Sace. = Apiosporina collinsii

219. Dimerosporium pulchrum Sace. (428, v. 1, p. 52)

On Cornus paniculata L'Her. (10, 522) 220. Diplocarpon rosae (Lib.) Wolf (535)

Syn. Actinonema rosae Lib.

On Rosa spp. (cult. rose) (15). Greenfield: Archer 1927 (Survey 1115)

221. Diplodia zeae Lev. (212)

On Zea mays var. indentata Bailey (corn) (15)

On Zea mays L. (corn) (15, 112, 113, 191, 406). Decorah: Holway 1882.

On Zea mays var.rugosa Bonaf. (sweet corn) (15, 191). Story City: Raleigh and Reddy 1927 (Survey 1157)

222. Discella populina Sacc. (6; 103; 428, v. 6, p. 562; 402)

On Populus sp. (cult. poplar) (15), Shenandoah: Muncie 1927 (Survey 1648); Bliss 1927 (Survey 1649)

On Populus alba nivea (Cy.) (cult. silver leaf poplar) (15). Shenan-doah: Bliss 1927 (Survey 1651)

On Populus nigra L. var. italica Du Roi (Lombardy poplar). Shenandoah: Bliss 1927 (Survey 1650)

Exsic. cited: Krieger F. sax. 997, 998, 2242, 2243; Barth. Fung. Col. 4126.

In the Iowa collections the pyenidia occur scattered on dead and living twigs and sometimes in well-defined cankers. The spores sometimes issue out through the ostiole in pinkish masses. They are $13.6-20 \times 3.4-5.5\mu$, irregularly fusoid, hyaline. They are filled with granular substance and usually have 2 large oil globules. Septa were found but rarely, even after considerable search. Petrak (402, p. 308-309), in fact, states that the septum is often indistinct. However, in Survey 1548 a few fruit bodies contained septate spores. The septa were slightly below the middle.

Petrak (402, p. 308-309) has combined this stem-inhabiting fungus with the leaf fungus, Marssonina, making the combination thus—Marssonina castagnei (Desm. & Mont.) Magn. forma populina (Sacc.) Petr. This combination is scarcely justifiable, based merely upon observational methods. He states that the spores of Discella populina and Marssonina

castagnei are quite similar.

However, the spores in examples of *M. castagnei* in Krieger F. sax. 997, 998, 2242, 2243, Fung. Col. 4126, have only a superficial resemblance to those in the Iowa collections. Although in the illustrations given by

Diedicke (103) for M. castagnei and Discella populina the spores are quite similar in shape and size and would thereby give weight to Petrak's combination,

Nevertheless, it would doubtlessly be best to consider the twig inhabiting fungus as Discella until actual culture and infection studies have been made.

223. Discosia artocreas (Fr.) Tode. (103, 435)

On Hepatica acutiloba DC. Ledges—Boone: Archer 1927 (Survey 1704)

Discula platani (Pk.) Sacc. = Gnomonia veneta

224. Doassansia alismatis (Nees) Cornu. (74, p. 69)

On Alisma sp. (245)

On Alisma plantago-aquatica L. (16, 72, 74). Algona: Hitchcock 1885-6. Decorah: Holway 1884 (Ell. N. Amer. Fung. 1485)

225. Doassansia deformans Setch. (74, p. 71) On Sagittaria latifolia Willd. (522)

226. Doassansia intermedia Setch. (74, p. 70) On Sagittaria latifolia Willd. (74)

227. Dothichiza populea Sacc. (214)

On Populus spp. (cult. poplar) (15, 406)

Dothidea graminis Fr. = Phyllachora graminis

Dothidea haydeni B. & C. = Phyllachora haydenii (B. & C.) Dearn.

228. Dothidella trifolii (Pers.) Bayliss-Elliott and Stansfield (48) Syn. Phyllachora trifolii (Pers.) Fckl., Polythrincium trifolii Kzc.

On Trifolium sp. (53)
On Trifolium pratense L. (341, 368, 380, 406, 522). Ames:

Bessey 1882¹; Halsted 1885**; Hitchcock 1895-6¹. Marathon:
Pammel 1908.

On Trifolium repens L. (8, 522). Ames: Gilman 1923. Dunbar:
Archer 1927 (Survey 777). Fayette: Wilson 1909 (Wilson & Seaver Ascom. & Low. Fung. 92)

Dothiorella smilacina (Pk.) Petr. & Syd. = Sphaeropsis cruenta

229. Empusa grylli (Fr.) Now. (428, v. 7, p. 282).

Syn. Entomophthora calopteni Bessey.

On Caloptenus differentialis Thomas (52). Ames: Bessey 1883.

230. Empusa muscae Cohn. (192)

Syn. Entomophthora muscae (Pers.) Fr.

On *Musca* sp. (house-fly) (522). *Ames:* Bessey 1880; Morrison 1900.

231. Endothia parasitica (Murr.) Anders. (11)

On Castanea sp. (Sorden var.) (15)

On Castanea dentata (Marsh.) Bork. (10, 15, 406). Osage: Archer 1927 (Survey 1385)

Entomophthora calopteni Bessey = Empusa grylli

Entomosporium maculatum Lev. = Fabraea maculata

232. Entyloma australe Speg. (74, p. 64)

Syn. Entyloma physalidis

On Physalis sp. (74). Decorah: Holway 1884**.

On Physalis lanceolata Michx. (74, 245). Ames: Crane 1896. Mason City: Pammel 1902.

^{&#}x27;Fide-C. R. Orton.

On Physalis pubescens L. (8, 15, 406) (cult. ground cherry). Cresco: Archer 1927 (Survey 1459)**. Decatur Co.: Anderson 1900. Ogden: Pammel 1903.

On Physalis pruinosa L. (255)

On Physalis heterophylla Nees. (245)

On Physalis subglabrata Mackenzie & Bush (245) On Physalis virginiana Mill. (16, 53, 72, 74, 245)

On Solanum nigrum L. (16, 53, 74)

Entyloma besseyi Farl. — Entyloma australe

233. Entyloma compositarum Farl. (74, p. 62)

On Ambrosia artemisiifolia L. (245, 522)

On Ambrosia trifida L. (522)

Clinton (74) has placed the Entyloma on species of Ambrosia from Iowa in *Entyloma polysporum* (Pk.) Farl,

On Bidens frondosa L. (522)

On Eupatorium urticaefolium Reichard (74)

On Lepachys pinnata T. & G. (16, 72, 74, 245, 522). Decorah: Holway 1884**. Jordan: Pammel 1927 (Survey 809). Grundy Center: Archer 1927 (Survey 541). Rockwell City: Archer 1927 (Survey 689)

On Rudbeckia laciniata L. (10). Decorah: Holway 1884**. Des Moines: Archer 1927 (Survey 1063)

Exsic. cited: Seymour & Earle, Ec. Fungi, C 18.

234. Entyloma crastophilum Sacc. (74, p. 60) On Phleum pratense L. (10, 72, 74, 245)

235. Entyloma eryngii (Cda.) DeBy. (74, p. 65) On Eryngium yuccifolium Michx. (72, 74)

236. Entyloma fuscum Schröt. (74, p. 66) On *Papaver* sp. (cult.) (376, 406).

Entyloma leuto-maculans Hume = Entyloma serotinum

237. Entyloma linariae Schröt. var. veronicae Wint. (74 p. 65)

On *Veronica peregrina* L. (72, 74). *Ames*: Gilman 1928 (Survey 1716); Halsted 1885**.

238. Entyloma lineatum (Cke.) Davis (74, p. 60)

On Zizania aquatica L. (74, 245). Decorah: Holway 1888*. Forest City: Pammel 1908.

239. Entyloma menispermi Farl. & Trel. (74, p. 61)

On Menispermum canadensis L. (16, 72, 74, 245, 522). Ames: Hume 1899. Decorah: Holway 1884 (Underw. & Cook Illust. Fung. 59). Winneshiek Co.: Goddard 1895.

240. Entyloma microsporum (Ung.) DeBy. (74, p. 66)

On Ranunculus sp. (74)

On Ranunculus septentrionalis Poir. (not R. repens as reported) (16, 74, 245)

241. Entyloma nymphaeae (D. D. Cunn.) Setch. (74, p. 66)

On *Castalia* sp. (72, 74)

On Castalia tuberosa (Paine) Greene (74, 522)

Entyloma pammelii Hume - Entyloma lineatum

Entyloma papaveris (376) — Entyloma fuscum

Entyloma physalidis (Kalchb. & Cke.) Wint. = Entyloma australe

242. Entyloma polysporum (Pk.) Farl. (73, 74, p. 62)

On Ambrosia artemisiaefolia L. (72, 74). Ames: Pammel 1909. Decorah: Holway 1884 (Ell. N. Amer. Fung. 1492b)

On Ambrosia trifida L. (8, 74, 522). Ames: Wright 1892.

243. Entyloma saniculae Pk. (74, p. 64-5)

On Sanicula sp. (522)

On Sanicula canadensis Torr. (245)

On Sanicula marilandica L. (72, 74). Decorah: Holway 1888**.

244. Entyloma serotinum Schröt. (74, p. 64) On Mertensia virginica DC. (72, 74, 245)

245. Epichloe typhina (Pers.) Trel. (443)

On Elymus virginicus L. Marshalltown: Pammel 1919.

On Muhlenbergia sp. (?). Grundy Center: Archer 1927 (Survey 786)

On Phleum pratense L. (389)

246. Erysiphe cichoracearum DC. (431)

On Actinomeris alternifolia (L.) DC. (Actinomeris squarrosa) (7, 8).

Ames: Carver 1892. Decatur Co.: Anderson 1904.

On Ambrosia artemisiifolia L. (7, 8, 368, 380, 522). Ames: Combs 1894.

Mondamin: Archer 1927 (Survey 1256)**. Decatur Co.: Anderson 1905.

On Ambrosia psilostachya DC. (7, 522)

On Ambrosia trifida L. (7, 8, 53, 218, 368, 380, 522). Ames: Bessey 1873, 1878; Combs 1894; King 1910. Decatur Co.: Anderson 1904. Fremont Co.: Anderson 1905. Ringgold Co.: Anderson 1905 (conidia only). Turin: Pammel 1894.

On Arctium minus Bernh. Ames: Carver 1892.

On Artemisia biennis Willd. (7). Ames: Combs 1894. On Artemisia canadensis Michx. Ames: Bettenga 1892.

On Artemisia ludoviciana Nutt. (7, 380). Ames: Carver 1892; Holway 1879; Pammel 1890.

On Artemisia serrata Nutt. (7, 199). Ames: Halsted 1887 (Ell. & Ev. N. Amer. Fung. 2nd Ser. 1944)

On Aster sp. (7, 522). Ames: Combs 1894.

On Aster cordifolius L. (7, 522). Decatur Co.: Anderson 1904 (conidia only)

On Aster laevis L. (7, 8, 522). Decatur Co.: Anderson 1904.

On Aster lateriflorus (L.) Britton. Decatur Co.: Anderson 1904.

On Aster multiflorus Ait. Ames: Combs 1894 (conidia only). Decatur Co.: Anderson 1904.

On Aster paniculatus Lam. Ames: Bessey 1877. Dubuque: Archer 1927 (Survey 1476)

On Aster puniceus L. (522)

On Aster sagittifolius Willd. (7, 522)

On Aster salicifolius Ait. (7, 522)

On Aster umbellatus Mill. Ames: Carver 1892.

On Chrysanthemum carinatum L. Winterset: Carver 1895. On Cirsium altissimum (L.) Spreng. (7, 199). Ames: Bessey 1882; Combs 1894; Pammel 1890. On Cirsium discolor (Muhl.) Spreng. (7, 8, 522). Ames: Carver 1892; Combs 1899. Decatur Co.: Anderson 1905. Osage: Archer 1927 (Survey 1378)

On Cosmos bipinnatus Cav. (7). Ames: Carver 1893.

On Cucumis sativus L. (cult. cucumber) (15, 406). Ames: Archer 1927 (Survey 1329)

On Cucurbita maxima Duchesne (cult. winter squash) (15). Ames:

Archer 1927 (Survey 1327)

On Cucurbita pepo L. (cult. pumpkin) (15, 406). Ames: Archer 1927 (Survey 1328); Dietz 1927 (Survey 1158)

On Dahlia pinnata Cav. Ames: Carver 1895.

On Eupatorium perfoliatum L. (7). Ames: Carver 1892 (conidia only)

On Eupatorium purpureum L. (7). Ames: ('arver 1892 (conidia only)

On Eupatorium urticaefolium Reich, (522)

On Galium circaezans Michx. (7, 8). Decatur Co.: Anderson 1903. On Grindelia squarrosa (Pursh) Dunal. Sioux City: Pammel 1895 (conidia only)

On Helenium autumnale L. (7, 8). Ames: Combs 1894.

On Helianthus sp. (7)

On *Helianthus annuus* L. (7, 368, 380, 406, 522). *Ames:* ('arver 1892. *Boone:* Pammel 1890.

On Helianthus debilis Nutt. (cult. eucumber sunflower) (15). Ames: Archer 1927 (Survey 1567)

On Helianthus doronicoides Lam. (7, 522). Ames: Bessey 1877.

On Helianthus giganteus L. (cult. giant sunflower) (15), Mondamin: Archer 1927 (Survey 1260)

On Helianthus grosse-serratus Martens (7, 8, 380). Ames: Combs 1894; Pammel 1909**. Decatur Co.: Anderson 1904.

On Helianthus laetiflorus Pers. (199)

On Helianthus petiolaris Nutt. Ames: Pammel 1909.

On Helianthus strumosus L. (199). Boone-Ledges: Coe 1912.

On Helianthus tuberosus L. (7, 8, 368, 380). Ames: Combs 1894; Rolfs 1891. Grinnell: Conard 1898**. Mondamin: Archer 1927 (Survey 1279)**

On Heliopsis scabra Dunal (7, 8, 522)

On Hydrophyllum canadense L. Ringgold Co.: Anderson 1905 (conidia only)

On Hydrophyllum virginianum L. (7). Ames: Hume 1899; Pammel and Rolfs 1891; Rolfs 1891.

On Lappula virginiana (L.) Greene (7, 199). Ames: Carver 1892 (conidia only). Decatur Co.: Anderson 1904 (conidia only)

On Parietaria pennsylvanica Muhl. (7, 522). Ames: Hume and Hodson 1899.

On Phlox spp. (cult.) (15)

On Phlox divaricata L. Decatur Co.: Anderson 1905.

On Phlox drummondii Hook. (7, 171, 522). Ames: Carver 1892 (conidia only); Bettenga 1892.

On Pilea pumila (L.) Gray (Adicea pumila) (7). Decatur Co.: An-

derson 1904.

On Plantago major L. (7, 8, 522). Ames: Lummis 1901. Decatur Co.: Anderson 1904.

On Plantago rugelii Dene. (7, 8, 522). Boone—Ledges: Coe 1912 (conidia only). Decatur Co.: Anderson 1904.

On Rudbeckia hirta L. (7)

On Rudbeckia laciniata L. (189)

On Scutellaria lateriflora L. (7, 522). Ames: Bessey 1878.

On Solanum carolinense L. Decatur Co.: Anderson 1905 (conidia only)

On Solidago sp. (406). Ames: Combs 1894.

On Solidago canadensis L. (7, 189, 522)

On Solidago rigida L. (7, 189, 522)

On Solidago serotina Ait. (7, 189)

On Solidago serotina var. gigantea (Ait.) Gray (522)

On Taraxacum officinale Weber. (199)¹

On Tragopogon porrifolius L. Ames: Carver 1895.

On Tragopogon pratensis L. Ames: Raeder 1921.

On Verbena bracteosa Michx. (522). Ames: Carver 1894. Decatur Co.: Anderson 1904 (conidia only)

On Verbena hastata L. (7, 8, 368, 380, 522). Ames: Combs 1894. Decatur Co.: Anderson 1904, 1905 (conidia only). Des Moines: Carver and Pammel 1895.

On Verbena stricta Vent. (7, 8, 368, 380, 522). Ames: Bessey 1877; Combs 1894; Paddock 1901; Pammel 1890; Stewart 1893. Fremont Co.: Anderson 1905.

On Verbena urticaefolia L. (7, 8, 368, 522). Ames: Bessey 1877; Blaine 1890. Decatur Co.: Anderson 1905. Decorah: Holway 1880 (?) (Ell. N. Amer. Fung. 424). Ringgold Co.: Anderson 1905.

On Verbesina sp. Ames: Pammel 1909.

On Verbesina helianthoides Michx. Ames: Carver 1892.

On Vernonia fasciculata Michx. (7). Ames: Combs 1894; Stewart 1894.

On Vernonia noveboracensis Willd. (7). Decatur Co.: Anderson 1904.

On Xanthium canadense Mill. (199). Des Moines: Carver 1895.

On Zinnia sp. (cult.) (15). Glidden: Archer 1927 (Survey 1590). Shenandoah: Archer 1926.

Erysiphe communis Grev. — Erysiphe polygoni

247. Erysiphe galeopsidis DC. (431).

On Mentha sp. (12)

On Mentha arvensis L. var. canadensis (L.) Briq. (189, 522)

On Scutellaria galericulata L. (7, 189)

On Scutellaria lateriflora L. (7, 171, 189, 522)

On Stachys palustris L. (7, 522). Ames: Ball 1898; Carver 1892.

On Teucrium canadense L. (7, 189)

^{&#}x27;Halsted (199) reported Erysiphe cichoracearum on this host, but as all the specimens of powdery mildew of this host in the Iowa State College Herbarium are referred to Sphaerotheca humuli, this report seems questionably authentic. This report was accepted earlier by Gilman (189).

248. Erysiphe graminis DC. (431)

On Agrostis alba L. (352). Clermont: Archer 1927 (Survey 574)

On Cinna arundinacea L. (12, 522)

On Elymus canadensis L. Ames: King 1912.

On Hordeum jubatum L. (189, 371) On Poa arachnifera Torr. (352)

On Poa palustris L. (352)

On Poa pratensis L. (7, 8, 15, 171, 218, 352, 383, 389, 406, 522).

Boone—Ledges: Coe 1912. Decatur Co.: Anderson 1900, 1905.

On Secale cereale L. (rye) (15)

On Sphenopholis obtusata (Michx.) Scribn. (352)

On Triticum vulgare Vill. (cult. wheat) (15, 352, 384, 406). Ames: King 1908, 1909, 1912; Pammel 1909, 1910, 1911.

Erysiphe lamprocarpa Kickx. = Erysiphe cichoracearum

Erysiphe linkii Lev. — Erysiphe cichoracearum Erysiphe martii Lev. — Erysiphe polygoni

249. Erysiphe polygoni DC. (431)

On Amorpha canescens Pursh. Ames: King 1910.

On Amphicarpa monoica Nutt. (380). Ames: Carver 1892.

On Amphicarpa pitcheri T. & G. (7, 8)

On Anemone sp. (7)

On Anemone canadensis L. (7)

On Anemone virginiana L. (7, 53). Ames: Bessey 1876.

On Anemonella thalictroides (L.) Spach. (7). Decatur Co.: Anderson 1905.

On Aquilegia sp. (cult. columbine) (15). Osage: Archer 1927 (Survey 1401)

On Astragalus canadensis L. (Astragalus carolinianus) (7, 8, 522, 530). Ames: Combs 1894. Boone—Ledges: Royse 1900. Decatur Co.: Anderson 1904. Decorah: Holway 1886.

On Brassica nigra (L.) Koch. (7, 8). Decatur Co.: Anderson 1900, Ibid.**

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On Brassica rapa L. (turnip) (15). Webb: Archer 1927 (Survey 1359)

On Clematis virginiana L. (7, 8, 53, 218). Ames: Bessey 187-, 1882; Hume 1899. Decatur Co.: Anderson 1904.

On Dahlia sp. (cult.) (10, 341, 342)

On Erysimum cheiranthoides L. (199)

On Geranium maculatum L. (7)

On Oenothera biennis L. (7, 522). Decatur Co.: Anderson 1904 (conidia only). Decorah: Holway 1879.

On Oxytropis lamberti Pursh, Turin; Pammel 1894. On Phaseolus lunatus var. macrocarpus Benth. (15)

On Phaseolus vulgaris L. (bean) (15). Ames: Archer 1927 (Survey 1325, 1331). Dubuque: Archer 1927.

On Pisum sativum L. (pea) (7, 8, 15, 53, 342, 383, 406)

On Polygonum acre HBK. (406)

On Polygonum aviculare L. (7, 8, 383, 406, 522). Ames: King 1910; Pammel 1909. Boone—Ledges: Coe 1912. Clarion: Melhus 1909 (conidia only). Decatur Co.: Anderson 1903. Grinnell: Conard 1923**. Ringgold Co.: Anderson 1905 (conidia only)

- On Polygonum erectum L. (7, 8, 522). Decatur Co.: Anderson 1904. 1905.
- On Polygonum ramosissimum Michx. (7). Ames: King 1908 (conidia only). Des Moines: King 1908 (conidia only). Fremont Co.: Anderson 1905 (immature). Greenfield: Archer 1927 (Survey 1116)
- On Ranunculus abortivus L. (7, 8, 368, 380, 522). Ames: Blake 1899; Dohrman 1899; King 1910. Decatur Co.: Anderson 1904 (conidia only)

On Ranunculus delphinifolius Torr. (368)

On Strophostyles helvola (L.) Britt. Mt. Pleasant: Mills 1897. On Thalictrum revolutum DC. (7, 8) Decatur Co.: Anderson 1905.

On Trifolium pratense L. (red clover) (15, 191, 406). Ames: Pammel 1922 (conidia only). Dubuque Co.: Pammel 1922 (conidia only). Kelley: Pammel 1922 (conidia only)

On Vigna sinensis Endl. (cult. cowpea) (15). Muscatine Co.: Gil-

man, Porter, Layton 1927 (Survey 1487)

250. Erysiphe taurica Lev. (431)

On Heliopsis scabra Dunal (522). Decatur Co.: Anderson 1904 (immature). Ringgold Co.: Anderson 1905 (immature)

Erysiphe tortilis (Wallr.) Fr. on Clematis virginiana = Erysiphe polygoni (See Salmon (431, p. 213))

251. Exobasidium mycetophilum (Pk.) Burt. (65)

On Armillaria mellea Fr. (525)

Exoascus aureus (Pers.) Sadeb. = Taphrina aurea

Expansion Expa

Exoascus communis Sadeb. — Exoascus pruni 252. Exoascus deformans (Berk.) Fekl. (186)

On Prunus persica (L.) Stokes (cult. peach). (Amygdalus L.) (8, 15, 53, 366, 368, 377, 383, 392, 406). Ames: Pammel 1886. Decatur Co.: Anderson 1904.

253. Exoascus farlowii (Sadeb.) Sacc. (39)

On Prunus serotina Ehrh. (392)

254. Exoascus mirabilis Atk. (39)

On Prunus sp. Luverne: Barton 1903.

On Prunus americana Marsh. (40, 392)

On Prunus angustifolia Marsh (39, 368, 406)

On Prunus hortulana Bailey. Randolph: Archer 1927 (Survey 876)

On Prunus hortulana var. mineri Bailey (miner plum) (15, 39, 40, 392, 406). Boone: Anderson 1913. Danbury: Booker 1902.

255. Exoascus pruni Fekl. (392)

On Prunus spp. (plum) (10, 15, 341, 342, 375, 406). Pottawattamie Co.: Burns 1927 (Survey 597) **

On Prunus americana Marsh. (8, 39, 53, 366, 368, 380, 383, 522)

On Prunus angustifolia Marsh, (179, 366)

On Prunus avium L. (10, 380)

On Prunus cerasus L. (10, 380)

On Prunus domestica L. (8, 380)

On Prunus hortulana Bailey (375)

On Prunus mahaleb L. (380)

On Prunus serotina Ehrh. (179)

256. Exobasidium vaccinii (Fekl.) Wor. (428, v. 6, p. 664)

On Rhododendron sp. (10)

257. Exosporium juniperinum (Ell.) Jacz. (121, 251)

Syn. Coryneum juniperinum Ell.

On Juniperus communis L. (121, 251). Decorah: Holway 1882 (Ell. N. Amer. Fung. 958)

258. Fabraea maculata (Lev.) Atk. (42)

On Amelanchier sp. (cult. Juneberry) (15). Shenandoah: Bliss 1927 (Survey 1630)

On Amelanchier spicata Lam. Ames: Carver 1892. McGregor: Pammel 1924.

On Cotoneaster sp. (350)

On Crataegus mollis (T. & G.) Scheele. Boone: Coe 1912.

On Crataegus oxycantha var. paulii (cult. Paul's hawthorn) (15). Shenandoah: Bliss 1927 (Survey 1537)

On Cydonia oblonga Mill. (quince) (Pyrus cydonia L.) (15, 350, 406). Shenandoah: Bliss and Gilman 1927 (Survey 921)

On Pyrus communis L. (cult. pear) (15, 355, 357, 359, 368, 406).

Ames: Anderson 1913; King 1912; Stewart 1893. Boone: Anderson 1913. Shenandoah: Bliss and Gilman 1927 (Survey 920)

On Pyrus malus L. (apple) (189, 350). Ames: Pammel 1889.

On Prunus serotina Rehd. var. culta Rehd. (P. sinensis Hort.). Ames: Carver 1892.

The literature is not clear as to whether the fungus on Crataegus should be considered the same as that on the other hosts or separated as *Entomosporium thuemenii* Sacc. The symptoms on this host differ from those on the pear and apple in the absence of the definite spot around the accryulus of the fungus.

259. Fomes fulvus Fr. (347)

On Prunus spp. (plum) (15). Osage: Archer 1927 (Survey 1375) On Prunus munsoniana Wight and Hedr. (15). Waterloo: Archer 1927 (Survey 1425)

260. Fusarium spp.

On Allium cepa L. (cult. onion) (406) On Avena sativa L. (cult. oats) (406)

On Brassica oleracea var. capitata L. (cult. cabbage) (406)

On Capsicum frutescens var. longum Bailey (Chili pepper) (15)

On Cucumis sativus L. (cult. cucumber) (406)

On Holcus sorghum L. (387)

On Holcus sorghum var. technicus Bailey (broomcorn) (387)

On Narcissus sp. (406)

On Pinus strobus L. (10, 342)

On Solanum tuberosum L. (cult. potato) (406)

On Zea mays L. var. indentata Bailey (15, 113, 314, 406). Ames: Combs 1894.

This is the purple leaf sheath spot described by Durrell (111) as being common on corn and due to various species of organisms.

261. Fusarium batatatis Wollenw. (538)

On Ipomoea batatas Lam. (sweet potato) (15, 191, 208, 406)

262. Fusarium betae (Desm.) Sacc. (356)

On Beta vulgaris L. (356)

With the more recent knowledge of the genus Fusarium, the fungus described by Dr. Pammel (356) under this name can be referred to this species only with great uncertainty. The authors did not see the specimen from Iowa which is reported to be in the New York Botanical Garden herbarium.

263. Fusarium conglutinans Wollenw. (187)

On Brassica oleracea var. capitata L. (cabbage) (15, 190, 191, 318)

264. Fusarium conglutinans var. callistephi Beach (49) On Callistephus chinensis Nees. (15, 406)

265. Fusarium culmorum Smith (453)

On Avena sativa L. (cult. oats) (342)

On Secale cereale L. (cult. rye) (342)

On Triticum vulgare Vill. (cult. wheat) (342, 360, 361, 368, 376, 383, 389)

266. Fusarium eumartii Carpenter (67)

On Solanum tuberosum L. (cult. potato) (406)

Fusarium gentianus (376) — Fusarium conglutinans

267. Fusarium herbarum (Cda.) Fr. (539)

On Melampsora bigelowii Thüm. on Salix lucida Muhl. (522)

On Melampsora medusae Thüm. on Populus deltoides Marsh. (522). On Puccinia graminis Pers. on Dactylis glomerata L. Manchester:

Pammel 1918.
On Puccinia menthae Pers. on Monarda mollis L. (522)

268. Fusarium hyperoxysporum Wollenw.

On Ipomoea batatas Lam. (15, 207, 208, 406)

269. Fusarium lini Bolley (55)

On Linum usitatissimum L. (cult. flax) (15)

270. Fusarium lycopersici Sace. (517)

On Lycopersicon esculentum Mill. (tomato) (15, 191, 406)

271. Fusarium martii phaseoli Burkh. (64)

On Phaseolus vulgaris L. (bean). Conesville: Layton 1928.

272. Fusarium martii pisi Jones (258) On Pisum sativum L. (pea) (15)

Fusarium moniliforme Sheld. - Gibberella moniliformis

273. Fusarium niveum EFS. (487)

On Citrullus vulgaris L. (cult. watermelon) (15, 191, 342, 408)

274. Fusarium orthoceras App. and Wollenw. (538)

On Ipomoea batatas Lam. (sweet potato) 275. Fusarium oxysporum Schl. (537, 538)

On Ipomoea batatas Lam. (cult. sweet potato) (15)

On Solanum tuberosum L. (cult. potato) (15, 340, 406) Albion: Greene 1910.

276. Fusarium oxysporum var. gladioli Massey (310)

On Gladiolus spp. (cult.) (406)

Fusarium parasiticum Ell. & Kell. = Fusarium herbarum

277. Fusarium radicicola Wollenw.

On Solanum tuberosum L. (cult. potato) (376, 406)

Fusarium roseum Link. - Fusarium culmorum

278. Fusarium trichothecioides Wollenw. (250)

On Solanum tuberosum L. (potato) (10, 67, 250)

Fusarium uredineum E. & E. - Fusarium herbarum

Fusarium urticearum (Cda.) Sacc. — Gibberella moricola

279. Fusicladium fasciculatum C. & E. (428, v. 4, p. 347)

On Euphorbia corollata L. Decorah: Holway 1884.

Exsic. cited: Ell. N. Amer. Fung. 545; Ell. & Ev. Fung. Col. 380; Barth. Fung. Col. 3234.

280. Fusicoccum castaneum Sacc. (428, v. 2, p. 666)

On Castanea sp. (Sorden var. chestnut) (15). Osage: Archer 1927 (Survey 1385)

Exsic. cited: Wilson & Seaver Ascom, and Low, Fung. 31.

This fungus does not seem to be reported in literature as the agent of a disease unless the Fusicoccum sp. causing cankers in California (Scott (436)) should prove to be same. In the Gardner Nursery at Osage, however, the fungus was fruiting plentifully in well defined cankers on young chestnuts.

These chestnuts are seedlings from the so-called blight-resistant variety developed by Sorden in Pennsylvania.

Fusiccocum veronense C. Massalongo — Gnomonia veneta Gibbera pulcaris Fr. — Gibberella saubinetii (Mart.) Sace.

281. Gibberella moniliformis (Sheld.) Wineland (531) On Zea mays L. (376, 531)

282. Gibberella moricola (Ces. & DeNot.) Saec. (103, 222, 225, 236, 539)

Syn. Fusarium urticearum (Cda.) Sace., Selenosporium urticearum Corda, Fusarium lateritium Nees var. mori Desm., Dendrodochium hymenuloides Sace., Myxosporium hymenuloides (Sace.) Höhn., Myxosporium diedicki Syd., Tubercularia hymenuloides (Sace.) Höhn., Tubercularia cruenta (Schw.?) Höhn., Pezizella cruenta (Schw.) in Ell. & Ev. Fung. Col. 1553.

On Morus sp. (cult. mulberry) (15). Lytton: Archer 1927 (Survey 697). Nora Springs: Archer and Layton 1927 (Survey

748), Shenandoah: Bliss 1927 (Survey 1518)

On Morus sp. (Downing var. mulberry). Shenandoah: Bliss

1927 (Survey 1521)

Exsic. cited: Allescher & Schnabl. F. bav. 599; Rabenhorst-Pazschke, F. eur. 4298; Bri. & Cav. F. par. 72; Thüm. Myc. univ. 375; Cavara, F. Longobardiae 88; Ell. & Ev. Fung. Col. 1553.

A study of the exsicati cited and of the Iowa collections leads to the conclusion that *Myxosporium hymenuloides* is a conidial state (microspore form) of *Gibberella moricola*.

Both the Myxosporium and the Fusarium stage occur abundantly in the state; the former evidently being a younger stage of the latter. In many cases it is impossible to distinguish between the two except by microscopic examination. In Thümen Myc. univ. 375 (Fusarium lateritium Nes.) a portion of the packet is Myxosporium hymenuloides.

In smaller and presumably younger fruiting structures (Survey 697 and 748) it was found that all transitional stages existed between the spores of Myxosporium hymenuloides and those of Fusarium urticearum. This

was especially true of the more or less incipient structures on the smaller twigs. Similarly an examination of Gibberella moricola (Cavara f. Long. 88) showed transition stages between the two types of spores in the younger fruiting structures. This was also true of Fusarium lateritium (Bri. & Cav. F. par. 72). The small 1-celled spore form depicted by Wollenweber (539, pl. 278) certainly is the same as those found in Myxosporium hymenuloides (cfr. Diedicke (103) p. 770, fig. 19b).

The specimen in Ell. & Ev. Fung. Col. 1553 evidently was issued erroneously as *Pezizella cruenta* (Schw.) Sacc. (cfr. Ell. & Ev. N. Amer. Fung. 2326). Höhnel (236, p. 69) is correct in considering this specimen to be nothing more than *Dendrodochium hymenuloides* Sacc., but he was mis-

taken in assuming it to be the Schweinitz species, Peziza cruenta.

283. Gibberella saubinetii (Mont.) Sacc. (35)

On Avena sativa L. (oats) (15, 191, 406)

On Hordeum vulgare L. (barley) (15, 191, 406). Des Moines: Rutledge. Harrison Co.: Porter 1928 (Survey 1720)

On Secale cereale L. (rye) (15, 191, 341, 406)

On Triticum vulgare Vill. (wheat) (15, 35, 341, 406). Ames: King 1914; Pammel 1908, 1909. Fonda: Buchanan 1914. Lucas: Hughes 1915. Osceola: Archer 1927 (Survey 890). Sloan: Iden 1914.

On Zea mays var. indentata Bailey (corn) (15, 113, 406, 529). Decorah: Holway 1882. Mount Pleasant: Seaver 1907 (Wilson & Seaver Ascom. & Low. Fung. 32)

284. Gloeodes pomigena (Schw.) Colby (76)

Syn. Leptothyrium pomi (Mont. & Fr.) Sacc.

On Pyrus malus L. (apple) (15, 406, 522). Decatur Co.: Anderson 1904.

Gloeosporium acerinum West. — Septoria aceris

285. Gloeosporium ampelophagum Sacc. (439)

Syn. Sphaceloma ampelinum DeBy.

On Vitis sp. (cult. grape) (15, 406). Belmond: Virden 1906. West Union: Pammel 1908.

On Vitis labrusca L. (8)

On Vitis labruscana Bailey (grape) (15)

Gloeosporium apocyni (Pk.) E. & E. = Cylindrosporium apocyni

286. Gloeosporium aridum Ell. & Holw. (134)

On Fraxinus sp. (10, 15, 406). Ames: King 1909.

On Fraxinus americana L. Ledges—Boone: Anderson 1913. Sac City: Archer 1927 (Survey 708)

On Fraxinus pennsylvanica var. lanceolata (Borkh.) Sarg. Ames: Archer 1927 (Survey 648).

Exsic. cited: Seymour & Earle, Ec. Fungi 519; Ell. & Ev. N. Amer. Fung. 2272.

287. Gloeosporium caulivorum L. Kirchner (327, 432)

Syn. Kabatiella caulivora (Kirch.) Karak.

On Trifolium pratense L. (red clover) (15) 288. Gloeosporium confluens Ell. & Dearn. (428, v. 14, p. 1012)

On Sagittaria latifolia Willd. (522)

289. Gloeosporium coryli (Desm.) Sacc. (103, 129)

On Corylus americana Walt. Decorah: Holway 1884.

Exsie. cited: Ell. & Ev. N. Amer. Fung. 2271; Barth. Fung. Col. 4729, 4822.

290. Gloeosporium davisii Ell. & Ev. (143)

On Lathurus venosus Muhl. (522)

Gloeosporium decipiens Ell. & Ev. - Gloeosporium aridum

Glocosporium melongenae Ell. & Halst. = Glomerella cingulata

Gloeosporium nervisequum (Fekl.) Sacc. — Gnomonia veneta

Gloeosporium platani (Mont.) Oud. - Gnomonia veneta

Glocosporium ribis (Lib.) Mont. & Desm. = Pseudopeziza ribis

291. Gloeosporium rubi Ell. & Ev. (137)

On Rubus nigrobaccus Bailey. Ledges-Boone: Coe 1912.

No exsicuti were available for comparisons, but this specimen fits the description so exactly that there can be little doubt but that it is the species. 292. Glocosporium saccharinum Ell. & Ev. (140)

On Acer sp. Ames: King 1909. Burlington: Higgins 1915.

On Acer nigrum Michx. (10, 15).

Exsic. cited: Barth. Fung. Col. 3433; Seym. & Earle Ec. Fung. 113a and 113b; Ell. & Ev. N. Amer. Fung. 2668.

Glocosporium toxicodendri E. & M. = Cylindrosporium toxicodendri

293. Gloeosporium trifolii Pk. (395)

On Trifolium sp. (376, 406)

Davis (90) considers this to be congeneric with Stagonospora dearnessii Sacc. (see under Mycosphaerella lethalis).

Gloeosporium venetum Speg. - Plectodiscella veneta

294. Glomerella cingulata (Stonem.) S. and v. S. (451) On Purus malus L. (8, 406). Ames: Anderson 1913.

On Solanum melongena L. (406)

Glomerella rufomaculans (Berk.) S. and v. S. = Glomerella cingulata

295. Gnomonia sp.

On Rhus glabra L. (13)

296. Gnomonia caryae Wolf. (534)

Syn. Gloeosporium caryae E. & D.

On Carya ovata (Mill.) Koch. Ames: Carver 1892, Burlington: Pammel 1918. Independence: Archer 1927 (Survey 1432)

297. Gnomonia leptostyla (Fr.) Ces. & DeNot. (285)

Syn. Marssonina juglandis (Lib.) Sacc.

On Carya sp. (10, 342, 376)

On Juglans cinerca L. (15, 361, 375, 380, 406, 522). Ames: Carver 1892; Hill 1907; Pammel 1890. Decorah: Holway 1885. Fayette: Wilson 1909 (Wilson & Seaver Ascom. & Low, Fung. 84). Ledges—Boone: Coe 1912. Shenandoah: Bliss 1927 (Survey 1008)

On Juglans nigra L. (15, 341, 342, 361, 375, 376, 380, 383, 406).

Ames: Bettenga 1892: Pammel 1909. New Hampton:

Archer 1927 (Survey 1447)

The specimen reported as Marssonina juglandis on Juglans cinerca by Anderson (8) has been found to be Microstroma juglandis.

298. Gnomonia tiliae Klebahn (286)

Syn. Gloeosporium tiliae Oud.

On Tilia americana L. Ledges—Boone: Archer 1927 (Survey 1579)

Exsic. cited: Rabenhorst-Pazschke, F. eur. 4190; Krieger, F. sax. 1149; Thüm, Myc. univ. 882.

The Iowa specimen was unique in that no conidia were found. However, immature beaked perithecia were abundant on leaves still attached to the tree.

299. Gnomonia ulmea (Schw.) Thüm.

On Ulmus sp. (15, 324, 341, 342, 406). Mondamin: Archer 1927 (Survey 1280). Vinton: Chadbourne 1912.

On Ulmus americana L. (324). Ames: Campbell 1909¹; Morrison 1900¹; Pammel 1910¹. Ledges—Boone: Anderson 1913¹; Coe 1912¹. Iowa City: Martin 1926**.

On Ulmus fulva L. Ames: Gilman and Archer 1927 (Survey 550).

Oelwein: Archer 1927 (Survey 757)

The material in survey 550 came from an eight year old tree which showed severe twig blighting and cankering early in the spring. The young twigs were blackened with a solid layer of the fungous stroma. A similar condition was found in the woods on young seedlings (Survey 757), where the young leaves were partially dwarfed.

300. Gnomonia veneta (Sacc. & Speg.) Kleb. (103, 284, 414)

Syn. Fusicoccum veronense C. Massalongo, Gloeosporium nervisequum (Fekl.) Sacc., Myxosporium valsoideum (Sacc.) All., Discula platani (Peck) Sacc.

On Platanus sp. (sycamore) (406). Ames: King 1909.

On Platanus occidentalis L. (8, 9, 15, 376, 377, 406). Ames: Anderson 1913; Archer 1927 (Survey 599). Cedar Rapids: Archer 1927. Pella: Kcables 1914. Shenandoah: Bliss 1927 (Survey 1314)

On Quercus spp. (15, 406)

On Quercus alba L. (white oak) (15, 406). Ames: Anderson 1913; King 1909.

On Quercus macrocarpa Michx. Boone: Archer 1927 (Survey 627)

301. Graphium gracile Pk. (396)

On Rubus idaeus L. var. aculeatissimus (Mey.) Reg. & Tiling (R. strigosus Michx.). Decorah: Holway 1884.

302. Guignardia aesculi (Pk.) Stewart (478)

On Aesculus glabra L. (Ohio buckeye) (8, 15, 361, 376, 377, 446).

Decatur Co.: Anderson 1905. Osage: Archer 1927 (Survey 1383)

On Assculus hippocastanum L. (horsechestnut) (10, 15, 199, 406). Shenandoah: Gilman and Bliss 1927 (Survey 919)

On Aesculus octandra Marsh. (Aesculus flava) (199, 446)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1723.

^{&#}x27;Identified by C. R. Orton as *Dothidella ulmi* (Duval) Wint. According to Miles (324), however, that species does not occur in America.

303. Guignardia bidwellii (Ell.) Vial. & Ravaz. (416, 468)

- On Psedera quinquefolia (L.) Greene (15, 199, 522). Cedar Falls:
 Archer 1927 (Survey 608). Decorah: Holway 1884. Hamburg:
 Pammel 1914. Postville: Pammel 1913. West Union: Pammel 1908.
- On Psedera quinquefolia var. hirsuta (Donn.) Rehd. (522)
- On Psedera tricuspidata Planch (cult.) (15). Shenandoah: Bliss 1927 (Survey 1632)
- On Vitis sp. (cult. grape) (15, 191, 406). Ames: Stewart 1893. Council Bluffs: Beach 1909. Lake City: Anderson 1912.

On Vitis sp. (wild grape) (15)

On Vitis aestivalis Michx. Randolph: Archer 1927 (Survey 878)

On Vitis labrusca L. (8, 383)

On Vitis labruscana Bailey (grape) (15, 83)

On Vitis rotundifolia Michx. (406)

- On Vitis vulpina L. (199, 446, 522, 530). Ledges—Boone: Coe 1912. Fayette: Wilson 1909 (Wilson & Seaver Ascom. & Low. Fung. 55)
- 304. Guignardia polygonati (Sacc.) Lindau (428, v. 9, p. 587) On Polygonatum commutatum (R. & S.) Dietr. (189)

305. Gymnoconia interstitialis (Schl.) Lagh. (25, p. 180 and p. 729)

Ou Rubus sp. (cult. blackberry) (15, 340, 406). Grinnell: Conard 1920**.

On Rubus sp. (wild blackberry) (522)

- On Rubus sp. Fairfield: Murray 1887**.
- On Rubus spp. (cult. raspberry) (8, 15, 317, 340, 341)

On Rubus allegheniensis Porter (blackberry) (25, 191)

On Rubus villosus Ait. (368, 383). Blockton: Campbell 1906**. Decorah: Holway 1885**, 1898*.

Arthur (25) reported this rust from Iowa on *Rubus allegheniensis* (p. 180), but in the corrections (p. 729) Iowa was stricken from the list of localities under this host.

306. Gymnosporangium clavariaeforme (Jacq.) DC. (25, p. 202)

On Amelanchier spicata (Lam.) C. Koch. (373)

On Juniperus communis L. (16, 25, 31). Clermont: Walker 1902^{1**}. Decorah: Holway 1882¹, 1882*.

Gymnosporangium claviceps C. & P. = Gymnosporangium germinale

307. Gymnosporangium corniculans Kern (25, p. 208) On Amelanchier canadensis (L.) Medic. (25, 31, 522) 308. Gymnosporangium germinale (Schw.) Kern (25, p. 197)

On Crataegus monogyna Jacq. Oskaloosa: Porter 1927 (Survey 1050) On Juniperus virginiana L. (16, 25, 373, 383, 406)

Exsic. cited: Ell. & Ev. Fung. Col. 1732.

309. Gymnosporangium globosum Farl. (25, p. 204)

On Crataegus sp. Des Moines: Case 1908. McGregor: Conard 1923**.
On Crataegus margaretta Ashe (25, 31). Columbus Jct.: Watson 1903.

On Crataegus mcgeeae Ashe (25, 31)

On Crataegus mollis (T. & G.) Scheele. (25, 31)

^{&#}x27;Fide-F. D. Kern.

On Crataegus pertomentosa Ashe (25, 31). Ames: King 1901¹.

On Crataegus punctata Jacq. (25, 31, 373, 522). Ames: Pammel 1901¹. Boone: Pammel 1901¹. Decorah: Holway 1885 (Barth. Fung. Col. 4929), Ibid.*; 1889 (Sydow Ured. 296), Ibid.*, 1885 (Barth. N. Amer. Ured 1308), Ibid.*. Mason City: Pammel 1902¹. Postville: King 1901¹.

On Crataegus rotundifolia Moench. (25, 31, 522)

On Crataegus tomentosa L. Decatur Co.: Anderson 1904.

On Juniperus virginiana L. (25, 31, 361, 373, 377, 383, 406, 522).

Ames: Schultz 1914. Cedar Point: Snyder 1927. Clermont:
Walker 1902. Decorah: Holway 1893*. McGregor: Smith 1927.

Winneshiek Co.: Goddard 1896.

310. Gymnosporangium juniperi-virginianae Schw. (25, p. 209)

On Crataegus sp. (406)

On Crataegus mollis (T. & G.) Scheele (406). Columbus Jct.: Watson 1902¹.

On Juniperus virginiana L. (16, 24, 25, 31, 53, 341, 342, 355, 361, 373, 380, 383, 406, 522). Ames: Bessey 1878; Bettenga 1892¹; Faurot 1901¹; Hitchcock 1885-6¹; Hume 1899¹; Pammel 1902**, 1892¹, 1907, 1908; Walker 1899¹, 1889 (Underw. & Cook, Illust. Fung. 43). Clermont: Walker 1902¹, 1902**. Decorah: Holway 1882*. Des Moines: Brown 1909. Harper's Ferry: Pammel 1906. Preston: McCulloch 1907**.

On Pyrus sp. (Whitney crab). Danbury: Booker 1906**.

On Pyrus coronaria L. (25, 31). Ames: Bessey 1882¹; Halsted 1885**; Kebler 1889; Pammel and Kebler 1889 (Seym. & Earle Econ. Fung. 227b), Ibid.*. Charles City: Arthur 1882 (Ell. N. Amer.

Fung. 1086a) Ibid.*. Wall Lake: Bessey 1879¹.

On Pyrus iocnsis (Wood) Bailey (15, 16, 25, 31, 355, 361, 368, 373, 380, 475, 522.) Ames: Bettenga 1892¹; Buchanan 1902; Faurot 1900; Hume 1899¹; Rolfs 1891¹. Blockton: Campbell 1906**. Boone: Anderson 1913. Cresco: Summers 1892. Decatur Co.: Anderson 1904. Marion Co.: Archer 1927 (Survey 1031)**. McGregor: Conard 1918**. Waukon: Pammel 1908.

On Pyrus ioensis var. plena Ar. (Beehtel erab) (15, 331). Shenan-

doah: Muncie & Archer 1926**.

On Pyrus malus L. (15, 25, 31, 191, 341, 373, 376, 383, 406, 522).

Ames: Sirrine 1905¹. Archer: Kiely 1914. Boone: Coe 1912.

Clarksville: Hodges 1914. Danbury: Booker 1906**. Decatur

Co.: Anderson 1897-1909. Fort Dodge: Reed 1918**. Glenwood: Greene 1911¹. Hesper: Pammel 1913. Kingsley: Forbes 1911. Lamoil: Hixon 1905¹. Larrabee: Arrasmith 1915.

Quimby: Harshberger 1914. Sloan: Montrose 1911. Sutherland: Draper 1911. Washta: Felter 1914. Williamsburg: Hull 1913. Woodbury Co.: Pammel 1906**.

Gymnosporangium macropus Lk. = Gymnosporangium juniperi-vir-

ginianae

^{&#}x27;Fide-F. D. Kern.

311. Gymnosporangium nidus-avis Thaxt. (25, p. 196)

On Amelanchier canadensis (L.) Medic. (25, 31)

On Juniperus virginiana L. (25, 31, 373, 377, 522). Annandale: Freeman 1901¹; Lyon 1899. Decorah: Holway 1893¹ 1893*; Holway 1893 (Barth. N. Amer. Ured. 910). West Union: Walker 1902¹.

312. Gymnosporium harknessioides Ell. & Holw. (154)

On Phryma leptostachya L. (154). Decorah: Holway 1884.

On Teucrium canadense L. Decorah: Holway 1884 (Rabenh-Wint. Fung. eur. 3389) (Ell. & Ev. N. Amer. Fung. 1392)

The authors (154) state that in all probability these are spore masses of some extraneous fungus that have lodged on the leaves of these plants. 313. Hadrotrichum lineare Pk. (398)

On grass (unnamed). Decorah: Holway 1883.

Exsic, cited: Rabenh, Winter Pazschke Fung, eur. 4098.

Haplosporella smilacis (E. & E.) Petr. & Syd. = Sphaeropsis cruenta

314. Helminthosporium spp.

On Hordeum vulgare L. (cult. barley) (406)

315. Helminthosporium avenae Eidam (106)

On Avena sativa L. (106, 406). Ames: Gilman 1929.

316. Helminthosporium gramineum Rabh. (106)

On *Hordeum vulgare* L. (barley) (15, 106, 191, 341, 522). *Ames:* King 1908, 1909², 1912², 1914; Pammel 1890², 1892², 1907, 1909, 1911. *Fayette:* Wilson 1909 (Wilson & Seaver Ascom. & Low. Fung. 56)

317. Helminthosporium sativum Pammel, King and Bakke (386)

On Festuca elatior L. (F. pratensis Huds.) (386). Ames: Pammel 1909.

On *Hordeum vulgare L.* (cult. barley) (15, 191, 386, 406). *Ames:* Bakke and King 1909² (type), 1910, 1912; Rolfs 1891².

On Triticum vulgare Vill. (wheat) (15, 69)

318. Helminthosporium stenacrum Drechsler (106)

On Agrostis alba L. Indianola: Archer 1927 (Survey 1068)

Helminthosporium teres Sacc. = Pyrenophora teres.

319. Helminthosporium turcicum Pass. (106) On Zea mays L. Ames: Gilman 1923.

Hendersonia desmazierii Mont. = Massaria platani

320. Hendersonia viburni Ell. (428, v. 3, p. 421)

On Viburnum lentago L. (428)

Heterosporium gracile Walls. - Didymellina iridis

321. Heterosporium hybridum E. & E. (138)

On Cleome serrulata Pursh. Mondamin: Archer and Muncie 1927 (Survey 1292)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 2188.

In the Iowa material, the leaves, seed pods, and stems were severely attacked.

^{&#}x27;Fide-F. D. Kern.

²Fide—A. G. Johnson.

The typical (?) Heterosporium spores described by Ellis & Everhart (138) were found but rarely; although the occasional one seen corresponded exactly with those in the example of Ell. & Ev. N. Amer. Fung. 2188. The spore most commonly seen was the Macrosporium (?) type described by Ellis and Everhart. These were quite irregular in shape and size; some short and muriform; others long with many cross walls, or sometimes muriform. From general appearances this fungus might be better considered as a species of Macrosporium.

322. Hopperburn (44)

On Solanum tuberosum L. (potato) (15)

323. Hyaloceras depazeoides (Otth.) Died. (103)

On Rosa sp. (cult.). Ames: Archer 1927 (Survey 1309)

324. Hyalopsora cheilanthus (Pk.) Arth. (25, p. 113)

On Cryptogramma stelleri (Gmel.) Prantl. (Pellaea gracilis Hook.) (16, 25, 31). Decorah: Holway 1882*.

325. Hyalopsora polypodii (DC.) Magn. (25, p. 112)

On Cystopteris fragilis Bernh. (Filix fragilis (L.) Underw.) (25, 31, 522). Ames: Gilman 1928 (Survey 1718). Decatur Co.: Anderson 1905.

326. Hypocrea citrina Fr. (443)

On Exidia glandulosa Fr. Decorah: Holway 1882.

327. Hypomyces hyalinus (Schw.) Tul. (443) On Agaricaceae (131)

328. Hypomyces lactifluorum (Schw.) Tul. (443)

On Lactarius sp. (522). Ames: Pammel and Seal 1925. Decorah: Holway 1882.

329. Hypomyces polyporinus Peck. (443)

On Polyporus versicolor L. (522)

Hypomyces van Bruntianus Ger. - Hypomyces hyalinus

330. Hypoxylon pruinatum (Klotzsch) Cooke (409) On Populus sp. Boone: Gilman 1924. Decorah: Holway 1882.

On Populus tremuloides Michx. (409)

Exsic. cited: Rabenh. Wint. Fung. eur. 3359.

331. Internal breakdown (407)

On Pyrus malus L. (cult. apple) (407)

332. Jonathan spot (437)

On Pyrus malus L. (cult. apple) (406, 437)

333. Kellermania yuccagena Ell. & Ev. (127) On Yucca filamentosa L. Ames: Howe 1926.

Kuehneola obtusa (Str.) Arth — Phragmidium obtusum. Kuehneola uredinis (Lk.) Arth. — Phragmidium uredinis.

334. Kunkelia nitens (Schw.) Arth. (25, p. 732)

Syn. Caeoma nitens (Schw.) Burr.

On Rubus sp. (cult. blackberry) (15)

On Rubus allegheniensis Porter (blackberry) (25, 31, 191). Decorah: Holway 1886 (Barth. N. Amer. Ured. 211), Ibid.*

Marion Co.: Pammel 1921.

On Rubus occidentalis L. (377). Council Bluffs: Pammel 1915. Eldora: Pammel 1927. Manly: Parker 1911.

On Rubus villosus Ait. (16, 377, 380). Ames: Hitchcock 1885-6,

Pammel—. Blockton: Campbell 1906. Decatur Co.: Anderson 1904. Decorah: Holway 1883*. Keokuk: Pammel 1923. Marshalltown: Dunn 1907.

Laestadia bidwellii Sacc. — Guignardia bidwellii

335. Leaf curl (50)

On Rubus sp. (cult. raspberry) (317, 406).

336. Leaf roll (434)

On Solanum tuberosum L. (potato) (15)

337. Leptosphaeria berberidis Rich. (428, v. 9, p. 780)

On Berberis vulgaris L. (15). Perry: Reddy 1927 (Survey 991)

The asci measured 54-70 x 14-20 μ , spores 20-25 x 6-7.5 μ , usually 3-4 septate.

338. Leptosphaeria coniothyrium (Fekl.) Sacc. (476)

Syn. Coniothyrium fuckelii Sacc.

On Rubus sp. (cult. black raspberry) (317, 406)

On Rubus occidentalis (16, 24). Greenfield: Stewart 1903.

339. Leptosphaeria heterospora (DeNot.) Niessl. (428, v. 2, p. 67) On Iris sp. (cult.) (15). Ames: Gilman 1928 (Survey 1627)

340. Leptosphaeria tritici (S. Garov.) Pass. (428, v. 2, p. 62) On Triticum vulgare Vill. (cult. wheat) (10, 110, 406)

Leptothyrium pomi (Mont. & Fr.) Sacc. = Gloeodes pomigena

341. Lophodermium juniperinum (Fr.) DeNot. (428, v. 1, p. 635)

On Juniperus communis L. (10) Decorah: Holway 1882 (Ell. & Ev. N. Amer. Fung. 999a)

Macrophoma smilacina (Pk.) Petr. & Syd. = Sphaeropsis cruenta

342. Macrosporium sp.

On Medicago lupulina L. Conesville: Archer 1927 (Survey 985)

On Medicago sativa L. (alfalfa) (15). Conesville: Layton 1927 (Survey 1047)

This organism occurs on leaves which are killed back from the tips and probably is the *Macrosporium sp.* reported in the check list (10) of Plant Diseases in the U. S. as the cause of a leaf blotch.

343. Macrosporium asclepiadum Cooke (428, v. 4, p. 528)

On Asclepias suriaca L. Des Moines: Carver 1893.

The characters agree with the original description (428, v. 4, p. 528) with the exception of spore measurements which, for the original material, are said to be $60-70 \times 10\mu$. On the Iowa collection they are $23-44 \times 10-13\mu$. 344. Macrosporium calycanthi Cav. (428, v. 10, p. 673)

On Calycanthus floridus L. (cult. common sweet shrub) (15). Shenandoah: Bliss 1927 (Survey 1546)

345. Macrosporium cucumerinum E. & E. (71)

On Cucurbita pepo L. (cult. squash). Ames: King 1910.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 3396.

346. Macrosporium longipes E. & E. (141)

On Nicotiana tabacum L. (cult.). Ames: Hume 1899.

347. Macrosporium tomato Cooke (71)

On Lycospersicon esculentum Mill. (cult.). Kingsley: Keir 1910. Exsic. cited: Ell. & Ev. N. Amer. Fung. 2484; Ravenel, F. am. 603.

Macrosporium solani E. & M. on Datura tatula = Alternaria crassum Macrosporuim solani E. & M. on Solanum tuberosum = Alternaria solani 348. Marssonina baptisiae Ell. & Ev. (147)

On Baptisia leucantha T. & G. (147, 428)

349. Marssonina brunnea (E. & E.) Sacc. (139)

On Populus spp. (cult. poplar) (15)

On Populus canadensis var. eugenei Scheele (cult. Carolina poplar) (15). Shenandoah: Bliss 1927 (Survey 1689)

Exsic. cited: Ell. & Ev. Fung. Col. 1267.

Marssonina fraxini Ell. & Davis = Cylindrosporium fraxini Marssonina juqlandis (Lib.) Magn. = Gnomonia leptostyla

350. Marssonina martini (S. & E.) Magn. (62, p. 26-27; 88, p. 254; 232, p. 203; 286, p. 199; 348, p.32; 435 p. 110)

On *Quercus sp.* (406). *Ames:* Crane 1896. *Mondamin:* Archer 1927 (Survey 1263)

On Quercus alba L. Shenandoah: Bliss 1927 (Survey 1687)

On Quercus macrocarpa Michx. (380, 383). Ames: Carver 1892. Waukon: Pammel 1908.

On Quercus robur L. (380). Ames: Wright 1892.

On Quercus rubra L. (15, 361). Shenandoah: Archer 1926 (Survey 1686, 1690); Bliss (Survey 1162)

Exsic. cited: Davis, Fung. Wis. 109; E. & E. N. Amer. Fung. 1632, 1629, 2268.

Most certainly the fungi called Marssonina martini (S. & E.) Magn. and Gloeosporium septorioides Sacc. are not different from Septoria querceti Thüm, except in stage of maturity. Likely Septoria dryina Cke. and S. serpentaria E. & M. are not distinct. In most of the Iowa collections the spores are strongly curved $10\text{-}24 \times 2\mu$, indistinctly 1 or more septate. Some of the specimens agree with the original description of Septoria querceti Thüm. (428, v. 3, p. 505)

Marssonina populi (Lib.) Sacc. - Pseudopeziza populi-alba

351. Marssonina thomasina (Sacc.) Magn. (92)

On Evonymus atropurpureus L. Ledges—Boone: Archer 1927 (Survey 624). Conesville: Layton 1927 (Survey 1026)

Exsic. cited: Davis, Fung. Wis. 95.

352. Marssonina violae (Pass.) Magn. (263)

On Viola sp. (cult.). Nashua: Burns 1927 (Survey 814)

On Viola cucullata Ait. Ames: Underwood 1924. Decatur Co.: Anderson 1903.

353. Massaria planati Ces. (428, v. 2, p. 6)

On Platanus occidentalis L. (9) 354. Melampsora abietis-canadensis (Farl.) Ludwig (25, p. 664)

On Populus sargentii Dode (Populus occidentalis (Ryd.) Britt.) (25, 31). Charles City: Arthur 1882 (Ell. N. Amer. Fung. 1075b)

355. Melampsora bigelowii Thüm. (25, p. 100 and p. 666)

On Salix amygdaloides Anderson (16, 25, 31, 53, 522). Ames: Bessey 1878; Blake 1899. Fraser: King 1911.

The specimen from Iowa on Salix exigua Nutt. (Salix luteosericea Rydb.) in Arthur's (25, p. 100) original list is omitted in the additions and corrections (25, p. 666)

356. Melampsora euphorbiae (Schubert) Cast. (25, p. 670) On Euphorbia cyparissias L. Redding: Muncie 1923.

Melampsora farinosa (Pers.) Schröt. = Melampsora humboldtiana

357. Melampsora humboldtiana Speg. (25, p. 668)

On Salix spp. (341, 380). Ames: Bessey 1882; Carver 1892; Halsted 1885**; Hume 1899; King 1911. Boone: Archer 1927 (Survey 1190)

On Salix bebbiana Sarg. Ames: Bakke 1907.

On Salix cordata Muhl. Ames: Pammel 1899.

On Salix fragilis L. Ames: Raymond 1891.

On Salix humilis Marsh. (522). Ames: Wright 1892.

On Salix interior Rowlee (Salix longifolia Auct.) (16, 25, 31, 522).

Ames: Carver 1892; Welch 1900; Wright 1892. Decatur Co.:
Anderson 1902.

On Salix lucida Muhl. (522). Ames: Bettenga 1892.

On Salix nigra Marsh. (8, 25, 31). Bedford: Bartholomew (Barth. N. Amer. Ured. 2622). Macksburg: Archer 1927 (Survey 1597)

There is much doubt as to the correctness of host determination in these specimens.

358. Melampsora lini (Schum.) Desm. (25, p. 101 and p. 670)

On *Linum sulcatum* Ridd. (25, 31, 178, 522). *Spirit Lake:* Arthur 1891.

On Linum usitatissimum L. (cult. flax) (25, 31, 406)

On Linum virginianum L. (178). Decorah: Holway 1885**.

359. Melampsora medusae Thüm. (25, p. 98 and p. 664)

On Populus balsamifera L. (16, 40). Decatur Co.: Anderson 1903. Grinnell: Conard 1923**.

On *Populus candicans* Ait. (Balm of Gilead) (15, 16, 25, 31, 53, 197, 368, 380, 522). *Charles City:* Arthur 1882 (Ell. N. Amer. Fung. 1075c), Ibid.*, *Shenandoah:* Bliss 1927 (Survey 1653)

On Populus deltoides Marsh. (Populus monilifera Ait.) (25, 31, 341, 342, 380, 522). Ames: Bessey 1874; Bettenga 1892; Blake 1899; Carver 1892; Crane 1896; Hill 1907; Hodson 1899; King 1910; Morrison 1900; Paddock 1901; Pammel 1890, 1891, 1911; Raymond 1891; Wright 1892. Columbus Jct.: Pammel 1899. Des Moines: Carver 1893. Fayette: Fink 1893. Iowa City: Martin 1924**. Spirit Lake: Arthur 1896**, 1904**.

On Populus occidentalis (Rydb.) Britton (25, 31). Charles City: Arthur 1882 (Ell. N. Amer. Fung. 1074, 1075b), Ibid.*.

Melampsora salicina on Salix amydaloides Anders. — Melampsora bigelowii

Melampsora salicina on Salix longifolia Muhl. = Melampsora humboldtiana 360. Melampsora ledicola (Pk.) Arth. (25, p. 119)

On Ledum groenlandicum Oeder. Ames: Dwigans 1899.

Exsic. cited: Ell. & Ev. Am. Fung. 2nd Ser. 1883.

Ledum groenlandicum is found only as an exotic in Iowa.

Melampsora populina Lev. (380) = Melampsora medusae

361. Melampsora pyrolae (DC.) Arth. (25, p. 118) On Pyrola elliptica Nutt. Decorah: Holway 1893 (Barth. N. Amer. Ured, 1012)

362. Melanconis juglandis (E. & E.) Graves (193)

Syn. Melanconium oblongum Berk.

On Juglans cinerea L. (10, 193, 406). Decorah: Holway 1882.

363. Melanconium bicolor Nees. (428, v. 3, p. 755)

On Betula sp. Decorah: Holway 1882 (Ell. & Ev. N. Amer. Fung. 2nd ser. 2390)

On Betula alba L. (15). Ames: Gilman 1927 (Survey 1629). Cherokee: Burns 1926.

On Betula alba var. papyrifera (Marsh.) Spach. Shenandoah: Bliss 1927 (Survey 1522)

Melanconium oblongum Pk. = Melanconis juglandis

364. Melanopsichium austro-americanum (Sp.) Beck. (74, p. 30)

- On *Polygonum* sp. (72, 74). *Ames:* Hume 1898. *Quarry:* Burt 1903.
- On Polygonum lapathifolium L. (Polygonum incarnatum) (16, 53, 74, 245, 522). Ames: Halsted 1885**; King 1910; Pammel 1906, 1909. Ottumwa: Williams 1902.

365. Melasmia galii E. & E.

On Galium boreale L. (522)

366. Microsphaera alni (Wallr.) Salmon (431)

On Alnus rugosa (Du Roi) Spreng. (Alnus incana (L.) Moench.) (7)

On Carpinus caroliniana Walt. (7, 10, 522)

On Catalpa bignonioides nana Hort. (umbrella catalpa) (7, 15). Shenandoah: Bliss 1927 (Survey 1658)

On Catalpa speciosa Warder. (7, 8, 218). Decatur Co.: Anderson 1900.

On Ceanothus americanum L. (7)

On Cornus alternifolia L. (522)

On Cornus paniculata L'Her. (7, 199)

On Corylus americana Walt. (7, 8, 218, 522). Ames: Bessey 1878; Stewart 1894. Decatur Co.: Anderson 1894.

On Corulus rostrata Ait. (199)

On Evonymus atropurpureus L. (7, 10, 522). Fremont Co.: Anderson 1906.

On Juglans nigra L. (cult. black walnut) (15). Shenandoah: Bliss 1927 (Survey 1532, 1657)

On Juglans regia L. (cult. Persian walnut) (15)

On Lathyrus odoratus L. (7, 406). Ames: Carver 1895; Crane 1896; Pammel 1908.

On Lathyrus palustris L. (7)

On Lonicera sp. (7, 368, 380). Ames: Bettenga 1892; Carver 1892; Crane 1896.

On Lonicera dioica L. Boone: Carver 1895.

On Lonicera flava Sims. (199). Decorah: Holway 1879. Delaware Co.: Thomas 1879.

On Lonicera sullivantii Gray. (7, 8, 522). Ames: Anderson 1913. Dillon: Anderson 1913. Fremont Co.: Anderson 1905.

On Lonicera tatarica L. (522). Ames: Pammel 1910.

On Lonicera tatarica var. alba (Hort.) (15). Shenandoah: Bliss 1927 (Survey 1654)

On Lonicera tatarica rosea Hort. (rosy tatarican honeysuckle) (15). Shenandoah: Bliss 1927 (Survey 1655)

On Lonicera tatarica siberica Hort. (red tatarican honeysuckle) (15). Shenandoah: Bliss 1927 (Survey 1656)

On Menispermum canadense L. (7)

On Ostrya virginiana (Mill.) K. Koch. (7, 8, 10, 522). Decatur Co.: Anderson 1905. Mondamin: Archer 1927 (Survey 1258)

On Quercus sp. (15, 406). Decorah: Holway 1885**.

On Quercus alba L. (522). Ames: Crane 1896; Pierce 1921. Union: Anderson 1913.

On Quercus macrocarpa Michx. (7). Ames: Carver 1892; Combs 1894; Pammel 1922.

On Quercus princides Willd. (7, 8). Decatur Co.: Anderson 1904. On Quercus robur L. (7, 368). Ames: Anderson 1913; Carver 1893.

On Quercus rubra L. (7, 53, 218, 363, 522). Ames: Bessey 1878; Osborn 1882. Boone: Pammel and Buchanan 1903. Steamboat Rock: Anderson 1913.

On Quercus velutina Lam. (7, 522)

On Sambucus sp. Ames: Pammel 1911.

On Syringa spp. (cult. lilae) (15)

On Syringa persica L. (341, 342, 368, 380). Ames: Anderson 1913;

Bettenga 1892; Pammel 1910.

On Syringa vulgaris L. (7, 8, 53, 171, 218, 368, 376, 380, 383, 406, 522). Ames: Bessey 1878; Carver 1892; Crane 1896; Hume 1899; Lummis 1901; Pammel 1908**; Raymond 1891. Boone: Coe 1912. Jordan: Buchanan 1903. Mason City: Pammel 1908. West Union: Pammel 1908**.

On Ulmus americana L. (7, 10, 522)

On Viburnum sp. Decorah: Holway 1879 (Ell. N. Amer. Fung. 432)

On Viburnum lentago L. (7, 171, 522). Decorah: Holway 1879 (Thüm. Myc. univ. 2055). Forest City: Bakke 1913. On Viburnum pubescens Ait. Winterset: Carver 1895.

On Vicia sp. (7)

The report of Microsphaera alni on Symphoricarpos sp. (363) was doubtless a mistake for M. diffusa.

367. Microsphaera diffusa Cke. & Pk. (431)

On Desmodium sp. (Meibomia sp.) Ringgold Co.: Anderson 1905. Decatur Co.: Anderson 1904, 1905. Fremont Co.: Anderson 1905.

On Desmodium canadense (L.) DC. (7, 8, 522) (not on D. sessilifolium (Torr.) T. & G. as reported (522)). Ames: Bessey 1878; Carver 1892; Hume 1899; Pammel 1910. Boone: Coe 1912. Decorah: Holway 1888**.

On Symphoricarpos spp. (cult. snowberry) (15)

On Symphoricarpos occidentalis Hook, Greenfield: Stewart 1893.

Mondamin: Archer 1927 (Survey 1264)

On Symphoricarpos orbiculatus Moench. (S. symphoricarpos) (cult. coralberry) (7, 8, 53, 218). Decatur Co.: Anderson 1904. Fremont Co.: Anderson 1905. Ringgold Co.: Anderson 1905.

On Symphoricarpos racemosus Michx, (cult. common snowberry) (15). Shenandoah: Archer 1927 (Survey 1310)

On Symphoricarpos vulgaris var. variegatus Hort. (cult. variegated coralberry) (15). Ames: Bessey 1880, 1882. Shenandoah: Bliss 1927 (Survey 1652)

Microsphaera elevata Burr. — Microsphaera alni Microsphaera extensa C. & Pk. — Microsphaera alni

368. Microsphaera euphorbiae (Pk.) B. & C. (431)

On Euphorbia corollata L. (7, 8, 171, 522). Decatur Co.: Anderson 1904. Decorah: Holway 1879 (Ell. N. Amer. Fung. 431). Ringgold Co.: Anderson 1905.

On Euphorbia marginata Pursh. (7)

Microsphaera friesii Lev. — Microsphaera alni

369. Microsphaera grossulariae (Wall.) Lev. (431)

On Sambucus canadensis L. (7, 171, 522). Ames: Pammel 1911 (conidia only)

Microsphaera hedgwigii Lev. - Microsphaera alni

Microsphaera quercina (Schw.) Burr. = Microsphaera alni

Microsphaera sumphoricarpi E. C. Howe = Microsphaera diffusa

370. Microsphaera russellii Clinton (431)

On Oxalis stricta L. (7, 8, 171, 218, 522). Ames: Bessey 1878; Carver 1893. Decatur Co.: Anderson 1905. Decorah: Holway 1878.

371. Microstroma juglandis (Bereng.) Sacc. (405)

On Carya laciniosa (Michx. f.) Lond. (406)

On Carya ovata (Mill.) K. Koch. (406). Osceola: Archer 1927 (Survey 891)

On Juglans cinerea L. (522). Decorah: Holway 1879, 1883**. Decatur Co.: Anderson 1902.

On Juglans nigra L. (199)

Exsic. cited: Seymour & Earle Ec. Fungi 159.

372. Mollisia dehnii (Rabenh.) Karst. (445)

On Potentilla sp. Iowa City: Seaver 1904 (Wilson and Seaver

Ascom. & Low. Fung. 15)

On Potentilla monspeliensis L. (8, 53, 199, 440, 445, 522). Ames: Gilman 1927 (Survey 653); Hitchcock-Halsted 1888 (?); (Ell. & Ev. N. Amer. Fung. 2nd Ser. 2039). Burr Oak: Goddard 1896. Decatur Co.: Anderson 1904. Shenandoah: Gilman 1927 (Survey 922)

Monilia sp. on Ostrya virginiana - Taphrina virginiana

Monilia angustior (Sacc.) Reade = Sclerotinia angustior

Monilia crataegi Died. — Sclerotinia johnsonii Monilia fructigena Pers. — Sclerotinia fructicola

Monilia gregaria = Sclerotinia gregaria

373. Monilochaetes infuscans Ell. & Halst. (209)

On Ipomoea batatas Lam. (sweet potato) (15, 208)

374. Mosaic (101, 161)

On Abutilon theophrasti Medic. (161)

On Achyrodes aureum (L.) Kuntze (161)

On Apium graveolens L. (celery) (161)

On Aquilegia caerulea James (161)

On Aquilegia canadensis L. (161)

On Asclepias syriaca L. (161)

On Calendula officinalis L. (15, 161)

On Capsicum fructescens L. (pepper) (315)

On Celtis occidentalis L. (cult. hackberry) (15). Shenandoah: Bliss 1927 (Survey 1634) This report may be considered doubtful since nothing has been found in the literature to substantiate it.

On Citrullus vulgaris Schrad. x "citron" (cult. watermelon) (15)

On Cucumis melo L. (cantaloupe) (15, 191, 316)

On Cucumis sativus L. (cult. cucumber) (15, 161, 191, 316, 406)

On Cucurbita sp. (gourd) (330)

On Cucurbita pepo var. condensa Bailey (squash) (161)

On Datura stramonium L. (82) On Euphorbia preslii Güss. (161) On Heliopsis scabra Dunal (161)

On Ipomoea batatas Lam. (sweet potato) (15)

On Lactuca scariola L. (12)

On Lycopersicon esculentum Mill. (tomato) (15, 161, 191, 376)

On Martynia louisiana Mill (161) On Nepeta cataria L. (161, 330) On Nicotiana tabacum L. (161)

On Paconia sp. (cult.) (15). Shenandoah: Bliss 1927 (Survey 838)

On Petunia violacea Lindl. (10, 161, 315) (not Petunia hybrida as reported) (161)

On Phaseolus vulgaris L. (bean) (15, 161, 191)

On Physalis longifolia Nutt. (82) On Phytolacca decandra L. (162)

On Rubus spp. (cult. raspberry) (15, 163, 191, 317)

On Rubus idaeus var. strigosus Maxim. (red raspberry) (161)

On Saccharum officinarum L. (sugar cane) (161)

On Soja max Piper (soybean) (161) On Solanum dulcamara L. (161, 315)

On Solanum melongena L. (egg-plant) (181, 182)

On Solanum nigrum L. (82)

On Solanum tuberosum L. (potato) (15, 161, 191)

On Spinacia oleracea L. (spinach) (15)

On Stokesia laevis Greene (Stokes aster) (161)

On Trifolium pratense L. (red clover) (15, 161). Pocahontas: Archer 1927 (Survey 1344)

On Verbena urticaefolia L. (12)

On Vernonia fasiculata Michx. (12)

On Vigna sinensis Endl. (cowpea) (15, 161). Conesville: Archer and Layton 1927 (Survey 953)

On Zea mays L. (corn) (161) On Zinnia elegans Jacq. (161)

375. Mycosphaerella aucupariae (Lasch) Laibach (288a)

Syn. Septoria sorbi Lasch, Septoria aucupariae Bres.
On Sorbus aucuparia L. (cult. European Mt. ash) (15). Shenandoah: Bliss and Gilman 1927 (Survey 926); Bliss 1927

(Survey 1145)

The study of the Iowa collections and two examples of Krieger F. sax. 795 would indicate a connection between *Phyllosticta sorbi* West, and *Septoria aucupariae* Bres. since they are often associated. (See under *Phyllosticta sorbi* pp. 375-376). In Iowa Survey 926 and 1145 and in Krieger material (795a) the pyenidia of the Septoria are to be found scattered on brown,

irregularly shaped spots. The ostioles are plainly visible on the upper leaf surface, often surrounded by a mass of exuded spores.

Exsic. cited: Krieger, F. sax. 795.

376. Mycosphaerella aurea Stone (481)

Syn. Septoria aurea E. & E.

On Ribes odoratum Wendl. (R. aureum in part) (502). Ames: Pammel 1893; Uppal 1924.

377. Mycosphaerella fragariae (Tul.) Lind. (435)

Syn. Ramularia tulasnei Sacc.

- On Fragaria sp. (cult. strawberry) (15, 199, 342, 406). Ames: King 1909. Ledges—Boone: Coe 1912. Mediapolis: Gustafson 1908.
- On Fragaria chiloensis Duch. (cult.) (8, 376). Council Bluffs: Anderson 1912.
- On Fragaria vesca L. (383). Ames: Lummis 1901.

On Fragaria vesca var. americana Porter (522)

On Fragaria virginiana Duch. (8, 383, 522, 530). Ames: Bettenga 1892. Decatur Co.: Anderson 1900.

The specimen of Mycosphaerclla fragariae collected by Crane (189) has been found to be Pezizella lythri.

378. Mycosphaerella grossulariae (Fr.) Lind. (481)

Syn, Septoria ribis Desm.

- On Ribes sp. (current) (15, 337, 340). Ames: Archer 1927 (Survey 1410)**. West Union: Pammel 1908**.
- On Ribes gracile Michx. (8, 502). Ames: Hume 1899. Muscatine: Pammel 1899.
- On Ribes grossularia L. (cult. gooseberry) (15, 199, 355, 383, 406). Shenandoah: Gilman and Bliss 1927 (Survey 916).
- On Ribes nigrum L. (cult. black currant) (10, 355, 357, 359, 380, 383, 481, 502). Ames: Carver 1892; Pammel 1900.
- On Ribes vulgare Lam. (current). Harpers Ferry: Pammel 1906.

The specimen reported as Septoria ribis on R. missourensis by Anderson (8) has been found to be Pseudopeziza ribis.

379. Mycosphaerella impatientis (Pk. & Clint.) House. (243)

On Impatiens biflora Walt. (199)

On Impatiens pallida Nutt. Decorah: Holway 1885.

Exsic. cited: Thum. Myc. univ. 963.

380. Mycosphaerella lethalis Stone (89, 223, 227, 400, 480)

Syn. Ascochyta lethalis E. & B. (according to Stone); Ascochyta meliloti (Trel.) Davis, Gloeosporium meliloti Trel., Marssonia meliloti Trel., Ascochyta caulicola Taub. (according to Davis); Stagonospora medicaginis (Rob.) Höhn., Septoria medicaginis Rob., Ascochyta medicaginis Bres. (according to v. Höhnel); Stagonospora meliloti (Lasch.) Petrak, Sphaeria meliloti Lasch., Septoria medicaginis Desm. & Rob., Septoria compta Sacc., Phleospora trifolii Cav., Stagonospora carpathica Baum., Septoria meliloti Sacc., Stagonospora trifolii Fautr., Stagonospora trifolii E. & E., Stagonospora dearnessii Sacc., Ascochyta caulicola Laub., Stagonospora medicaginis Höhn., Stagonospora compta Died. (according to Petrak)

On Melilotus alba Desr. (cult. white sweet clover) (15). Adel: Gilman and Archer 1927 (Survey 831). Sac City: Archer and Layton 1927 (Survey 712a)

On Melilotus officinalis (L.) Lam. (yellow sweet clover). Ames:

Gilman 1927 (Survey 893).

Exsic. cited: Krieger, F. sax. 1384 (Septoria meliloti Sacc.); Ell. & Ev. Fung. Col. 1808.

The spores in Survey 712a were about 20μ long with 1-3 cross walls and could, therefore, be considered as a Septoria or Stagonospora. However, Petrak (400, p. 64) has pointed out the variability of this fungus, so that it is possible to find it at one time as an Ascochyta and again as a Stagonospora or Septoria. Stone (480, p. 488) mentions the presence of biseptate spores. An examination of Septoria meliloti Sacc. (Krieger F. sax. 1384) showed that the younger pycnidia contained short, 1-septate spores which were indistinguishable from Ascochyta lethalis, i. e. in Survey 831 and 893.

In the taxonomic literature there is much confusion in the disposition of this fungus. Many authors (see above), have attempted synonomy. That given by Petrak combines the forms occurring on Trifolium, Medicago and Melilotus. Whether these are all actually the same fungus or not can be determined only by cross inoculations. However, until the time such inoculations are attempted it will be desirable to accept the synonomy listed by Petrak with the added synonomy of Davis.

It would seem from these studies that if the rules of priority were to be followed that the name applied by Stone to the perfect stage should be rightfully $Mycosphaerella\ meliloti$ and not $M.\ lethalis$. However in this respect v. Höhnel (227) has already changed $Mycosphaerella\ lethalis$ (Lasch.) Stone to $Didymellina\ lethalis$ (Lasch.) Höhn. This last change can be accepted only upon further and more extensive study.

381. Mycosphaerella pinodes (B. & B.) Stone (261, 295)

Syn. Ascochyta pisi Lib.

On Pisum sativum L. (cult. pea) (406). Decorah: Holway 1883. 382. Mycosphaerella rubi Roark. (422)

Syn, Septoria rubi West.

On Rubus sp. (blackberry) (15). Mondamin: Archer 1927 (Survey 1259)

On Rubus spp. (raspberry) (15, 191, 317)

On Rubus allegheniensis Porter, cult. blackberry) (502). Ledges—Boone: Coe 1912.

On *Rubus canadensis* L. (cult.) (8, 380, 502). *Ames*: Raymond 1891.

On Rubus flagellaris Willd. (502). Mason City: Pammel 1908. Muscatine: Pammel 1899.

On Rubus occidentalis L. (cult. black raspberry) (522). Ames: Gilman 1923.

On Rubus odoratus L. (cult.) (199, 380, 502). Ames: Carver 1902.

383. Mycosphaerella sentina (Fr.) Schröt. (435, 468)

On Pyrus communis L. (cult. pear) (406). Lamoni: Anderson 1913. Exsic. cited: Ell. & Ev. Fung. Col. 583; Barth. Fung. Col. 4284.

384. Mycosphaerella thalictri (E. & E.) Lindau. (125; 293; 428, v.9, p. 612) On Thalictrum dioicum L. (125). Grundy Center: Archer 1927 (Survey 771).

On Thalictrum polygamum Muhl. (Thalictrum cornuti T. & G.). Decorah: Holway 1884**.

Exsic. cited: Barth, Fung. Col. 4080.

385. Mycosphaerella ulmi Kleb. (324)

Syn. Pleospora ulmi (Fr.) Wallr.

On Ulmus fulva Michx. (502). Decorah: Holway 1884 (Ell. & Ev. N. Amer. Fungi 1617).

386. Myxosporium ellisii Sacc. (428, v. 3, p. 724)

On Populus alba L, var. pyramidalis Bunge. (428)

387. Myxosporium tulipiferae Died. (103)

On Liriodendron tulipifera L. Shenandoah: Bliss 1927 (Survey 1628) The spores were spindle shape, 8-10 x 3-3.5μ, hyaline multiguttulate.

The fruiting bodies were closely crowded in well defined cankers.

Myxosporium valsoideum (Sacc.) All. = Gnomonia veneta.

Napicladium tremulae (Frank) Sacc. = Venturia tremulae,

Neocosmospora vasinfecta var. nivea EFS. = Fusarium niveum.

388. Neottiospora sp.

On Yucca gloriosa L. Cedar Rapids: Archer 1927 (Survey 609).

Plants in a park at Cedar Rapids had many dead leaves on which the pycnidia of this fungus occurred in great abundance.

389. Neovossia iowensis Hume & Hodson (74, p. 53)

On Phragmites communis Trin. (72, 74, 219, 245, 390). Colo: Hodson 18991 (type). Eagle Grove: Buchanan 1903.

Neovossia moliniae (Thüm.) Körn. — Neovossia iowensis. 390. Nummularia discreta (Schw.) Tul. (80)

On Amelanchier canadensis (L.) Medic. (15). Ledges-Boone: Gilman 1924.

On Pyrus communis L. (cult. pear) (15). Osage: Archer 1927 (Survey 1381).

On Pyrus malus L. (cult. apple) (15, 191, 373, 376, 377, 385, 406, 522). Ledges-Boone: Coe 1912.

On Sorbus sp. (cult.). Des Moines: Nichols 1927 (Survey 1146).

On Sorbus aucuparia L. (cult. European mountain ash) (15). Osage: Archer 1927 (Survey 1382)

The name Nummulariola has been suggested by House (244) to replace the fungus genus name Nummularia but the authors have retained the old name because of its common usage.

391. Nyctalis asterophora Fr. (268)

On Russula sp. Ames: Cation 1928.

392. Oidium sp.

On Evonymus americanus L. (cult.). Shenandoah: Archer & Muncie 1926**.

393. Olpidium saprolegniae Braun. (172)

On Achyla sp. (410).

Oospora scabies Thaxt. = Actinomyces scabies.

Ophidothis haydeni (B. & C.) Sacc. = Phyllachora haydeni.

¹Fide—G. P. Clinton.

Otthia morbosa (Schw.) E. & E. = Plowrightia morbosa.

394. Ovularia isarioides Sacc. (395)

On Staphylea trifolia L. Decorah: Holway 1885 (Ell. & Ev. N. Amer. Fung. 1643).

395. Ovularia obliqua (Cke.) Oud. (428, v. 4, p. 145)

On Rumex sp. Decatur Co.: Anderson 1903. Decorah: Holway 1883.

On Rumex altissimus Wood. Menlo: Archer 1927 (Survey 1148)

On Rumex crispus L. Ames: Carver 1892.

On Rumex patientia L. Ames: Bakke 1907.

Exsic. cited: Barth, Fung. Col. 5039; Ell. & Ev. N. Amer. Fung. 220; Bri. & Cav. F. para. 386.

396. Papery leaf spot (non-parasitie) (516)

On Panax quinquefolia L. (cult. ginseng) (15).

397. Parodiella grammodes (Kze.) Cke. (142)

Syn. Parodiella perisporioides (B. & C.) Speg.

On Desmodium canadense L. Ames: Carver 1892. Decorah: Holway 1884, 1888**.

Exsic. eited: Barth. Fung. Col. 2643.

398. Penicillium expansum Link. (494)
Syn. Penicillium glaucum L.
On Pyrus malus L. (341)

399. Penicillium gladioli McC. & Thom (301) On Gladiolus sp. (164).

400. Peronospora alsinearum Casp. (172)

On Cerastium nutans Raf. (299, 410). Decorah: Holway 1888**.

401. Peronospora alta Fekl. (172)

On Plantago sp. (406).

On Plantago major L. (54, 299, 380, 410, 522). Ames: Pammel 1900, 1909¹. Decorah: Holway 1884.

On *Plantago rugelii* Dene. (410). *Ames:* King 1912; Pammel 1909, 1917.

402. Peronospora arenariae (Berk.) DeBy. (172) On Silene antirrhina L. Ontario: Faurot 1900.

403. Peronospora arthuri Farl. (172)

On Gaura biennis L. (8).

On Oenothera biennis L. (13, 54, 299, 410, 483, 522). Decatur Co.: Anderson 1905. Decorah: Holway 1884 (Rabenh. Wint. Fung. eur. suppl. 3072) (Ell. & Ev. N. Amer. Fung. 2nd. Ser. 1407). Spirit Lake: Halsted 1885**.

404. Peronospora calotheca DeBy. (172)

On Galium sp. (410).

On Galium aparine L. (410, 483). Decorah: Holway 1884.

On Galium borcale L. (299, 410, 522, 530). Fayette: Wilson 1909 (Wilson & Seaver Ascom. & Low. Fung. 62)

405. Peronospora chamaesycis Wilson (523) On Euphorbia maculata L. (83, 523).

406. Peronospora chenopodii Schlecht. (172)

On Chenopodium album L. (522).

On Chenopodium album var. viride (L.) Moq. (522).

On Chenopodium hybridum L. (522).

¹This specimen was reported (410) as Peronospora effusa.

407. Peronospora echinospermi Sw. (483)

On Lappula virginiana (L.) Greene (522).

408. Peronospora effusa (Grev.) Rabh. (172)

On Chenopodium sp. (410). Decorah: Holway 1885. On Chenopodium album L. (38, 54, 202, 299, 410, 483, 522). Ames: Hitchcock 1885-6. Conesville: Layton 1927 (Survey 901). Spirit Lake: Halsted 1885**.

The specimen collected by Dwigans in 1899 (410) has been found to be a fungus other than a Peronospora.

On Chenopodium hybridum L. (299, 522).

On Spinacia oleracea L. (cult. spinach—under glass) (15). Ames: Gilman 1928 (Survey 1684).

409. Peronospora euphorbiae Fckl. (172)

On Euphorbia alyptosperma Engelm, (299).

On Euphorbia maculata L. (202, 299, 380, 410, 522), Fayette: Wilson 1909 (Wilson & Seaver Ascom. & Low. Fung. 88)

On Euphorbia preslii Guss. (380, 410).

On Euphorbia serpyllifolia Pers, (197, 229, 410). Ames: Hitchcock 1885-6.

410. Peronospora ficariae Tul. (172)

On Ranunculus septentrionalis Poir. (299, 410) (not Ranunculus repens as reported). Decorah: Holway 1885, 1886**.

411. Peronospora fragariae Roze & Cornu (523)

On Fragaria sp. (523).

Peronospora gangliformis DeBy. = Bremia lactucae. Peronospora gonoboli Lagerh. = Plasmopara gonoboli.

412. Peronospora hydrophylli Waite.

On Ellisia nuctelea L. Ames: Melhus 1924.

On Hydrophyllum virginianum L. (299, 410, 483, 504, 522), Ames: Melhus 1924; Pammel 1914. McGregor: Pammel 1918.

413. Peronospora lamii A. Braun (172)

On Salvia lanceaefolia Poir. Glidden: Pammel 1912.

414. Peronospora lepidii (McAlp.) Wilson (523)

On Lepidium apetalum Willd. (523).

On Radicula palustris (L.) Moench. (523).

415. Peronospora leptosperma DeBy. (172)

On Artemisia biennis Willd. (54, 202, 299, 410). Spirit Lake: Halsted 1885**.

On Artemisia ludoviciana Nutt. (202, 410). Decorah: Holway 1884.

On Artemisia serrata Nutt. Decorah: Holway 1884**, 1885 (Ell. & Ev. N. Amer. Fung. 2nd Ser. 1804).

416. Peronospora lophanthi Farl. (172)

On Agastache sp. Decorah: Holway 1888**.

On Agastache nepetoides (L.) Kuntze. Ames: Melhus 1924. Decorah: Holway 1884.

On Agastache scrophulariaefolia (Willd.) Kuntze. (197, 202, 299, 410), Ames: Hitchcock 1885-6; Pammel 1924, Decorah: Holway 1884 (Ell. & Ev. N. Amer. Fung. 1413).

Peronospora obducens Schröt. = Plasmopara obducens.

^{&#}x27;Ellisia nyctelea L. has not been reported previously as a host for this mildew insofar as the authors could determine.

417. Peronospora parasitica (Pers.) Tul. (172)

On Brassica arvensis (L.) Ktze. (410)

On Brassica campestris L. (10, 380, 410).

On Brassica juncea L. Boone: Archer 1927 (Survey 1189).

On Brassica nigra (L.) Koch, (197, 299, 380, 410),

On Brassica oleracea var. capitata L. (cult. cabbage) (406).

On Capsella bursa-pastoris L. (8, 54, 299, 366, 368, 380, 383, 410). Ames: Archer 1927 (Survey 650)**. Ledges-Boone: Archer 1927 (Survey 629).

On Dentaria laciniata Muhl. (299, 410, 530). Fayette: Wilson 1908

(Wilson & Seaver Ascom. & Low, Fung. 63)

On Draba caroliniana Walt. (380, 410, 522).

On Erysimum parviflora Nutt. (522)

On Lepidium sp. (410). Decatur Co.: Anderson 1904.

On Lepidium apetalum Willd. (Lepidium intermedium) (8, 366, 368, 380, 406, 410, 522). Ames: Pammel 1911, 1918.

On Lepidium virginicum L. (202, 299, 380, 410)

On Radicula palustris (L.) Moench. (197, 202, 299, 410). Rockwell City: Archer 1927 (Survey 695).

On Raphanus sativus L. (cult. radish) (406).

On Sisymbrium canescens Nutt. (8, 299, 410). Crescent: Pammel 1901. Fairport:—1913.

On Sisymbrium officinale (L.) Scop. (8, 380, 410)

418. Peronospora phlogina D. & H. (105)

On Phlox divaricata L. (299). Nevada: Melhus 1924.

419. Peronospora polygoni Thüm. (172)

On Polygonum aviculare L. (202, 299, 410). Ames: King 1912.

On Polygonum convolvulus L. (202).

On Polygonum dumetorum L. (202). Spirit Lake: Halsted 1885**. On Polygonum scandens L. (299, 410).

420. Peronospora potentillae DeBy. (172)

On Agrimonia gruposepala Wallr. (410). Ames: Melhus 1916. Humboldt: Archer 1927 (Survey 1219).

On Agrimonia mollis (T. & G.) Britton (522).

On Geum canadense Jacq. (522).

On Potentilla sp. New Sharon: Hume 1899.

On Potentilla monspeliensis L. (8, 54, 202, 368, 410, 522). Ames: Hitchcock 1885-6. Decatur Co.: Anderson 1904.

On Potentilla monspeliensis var. norvegica (L.) Ryd. Decorah: Holway 1888**. Spirit Lake: Halsted 1885**.

Peronospora pygmaea Ung. = Plasmopara pygmaea.

421. Peronospora schleideni Ung. (172) On Allium cepa L. (cult. onion) (406).

422. Peronospora seymourii Burr. (526)

On Houstonia patens Ell. (Houstonia minor (Michx.) Britton) (526).

423. Peronospora sordida Berk. & Br. (172)

On Scrophularia marilandica L. (202, 299, 410). Ames: Bessey 1882. Decorah: Holway 1884. Fayette: Wilson 1909. (Wilson & Seaver Ascom, and Low, Fung. 90) (not S. nodosa as reported by Bessey and Holway).

424. Peronospora sparsa Berk. (172)

On Rosa sp. (410). Sioux City: Raeder 1914.

The specimen in the herbarium shows no downy mildew.

425. Peronospora trifoliorum DeBy. (172)

On Astragalus canadensis L. (184, 197, 202, 299, 352, 410, 522). Fayette: Wilson 1908 (Wilson & Seaver Ascom. Low. Fung. 64).

On Medicago lupulina L. (391).

On Medicago sativa L. (alfalfa) (15, 191, 391, 406). Ames: Archer 1927 (Survey 1056)**; Melhus 1925.

On Melilotus officinalis (L.) Lam. (yellow sweet clover). Ames: Kopf

1929.

The Peronospora trifoliorum reported on Vicia americana (54, 197, 202, 352, 410) has in all cases where material was available for study proven to be Peronospora viciae. Gäumann (184) has referred the form on Astragalus canadensis to Peronospora astragali Syd.

426. Peronospora urticae DeBy. (172)

On Laportea canadensis (L.) Gaud. (299, 410).

427. Peronospora viciae DeBy.

On Pisum sativum L. (10).

On Vicia americana Muhl. (54, 202, 229, 352, 380, 410, 522) Ames: Gilman 1927 (Survey 533)**; Halsted 1885**; Hitchcock 1885-6; Melhus 1924. Decorah: Holway 1884 (Ell. N. Amer. Fung. 1408)

428. Pezizella lythri (Desm.) Shear & Dodge (449, 471)

Syn. Hainesia lythri (Desm.) Höhnel, Sclerotiopsis concava (Desm.) Shear & Dodge.

On Fragaria sp. (cult. strawberry). Ames: Crane 1896.

Phacidium medicaginis = Pseudopeziza medicaginis.

Phacidium repandum - Mollisia dehnii.

Phleospora aceris (Lib.) Sacc. = Septoria aceris.

429. Phleospora anemones E. & K. (305, p. 88)

On Anemone cylindrica Gray, Jewell Jct.: Carver 1895.

Exsic. cited: Ell. & Ev. Fung. Col. 1945.

Original description:

"Leaf slightly yellowish and sprinkled with reddish-purple specks, indicating the position of the perithecia, which are distinctly prominent below, with a large opening through which issue in pale cirrhi the oblong-cylindrical, hyaline, nucleate, finally 3-septate sporules which are 25-40µ long and about 37 thick."

Spores of the Iowa specimen measure 10μ longer than the original description. They are broadest at the base and taper to a point at the

apex.

430. Phleospora maculans (Bereng.) Allesch. (5, 346)

On Morus alba L. Ames: Carver 1892.

Exsic cited: Seymour & Earle, Ec. Fungi 151; Ell. & Ev. N. Amer. Fung. 2450; Barth. Fung. Col. 3155; Allescher & Schnabl. F. bav. 680; Thüm. myc. univ. 694; Bri. and Cav. F. par. 21.

Phleospora ulmi (Fr.) Wallr. = Mycosphaerella ulmi.

431. Phoma anethi (Pers.) Sacc. (103)

On Anethum graveolens L. (cult. dill) (15, 406). Marion: Archer 1927 (Survey 1477). Muscatine: Porch 1927**.

432. Phoma baccicola Rich. (428, v. 10, p. 145)

On Symphoricarpos racemosus Michx. (Symphoricarpos albus Blake).

Ames: Gilman 1924.

433. Phoma berberina Sacc. (428, v. 3, p. 72)

On Berberis vulgaris L. (15). Spencer: Porter 1927 (Survey 1153). The minute pycnidia were produced abundantly on living stems. The spores measured $5.9-6.9 \times 2-2.5\mu$.

434. Phoma betae (Oud.) Frank (114)

On Beta vulgaris L. (sugar beet) (15).

435. Phoma destructiva Plowr. (249)

On Lycopersicon esculentum Mill. (406).

436. Phoma iowana Sacc. (428, v. 3, p. 143) On Aster ptarmicoides T. & G. (428).

437. Phoma lingam (Tode) Desm. (216)

On Brassica oleracea var. capitata L. (cult. cabbage) (191, 216, 406).

Marshalltown: Gilman 1928.

438. Phoma longissima (Pers.) West. (5)

On Chenopodium album L. Ames: Dwigans 1899.

The specimen was erroneously quoted by Raeder (410) as *Peronospora effusa* Rabh. but examination proves it to be the above Phoma. Comparisons were made with Allescher and Schnabl. Fung. Bav. 270 and the two fungi were shown to be identical. Our specimen is slightly immature.

Exsic. cited: Allesch. & Schn. Fung. bav. 270.

439. Phoma virginiana Ell. & Halst. (152) On Prunus virginiana L. (152, 199).

440. Phomopsis juniperovora G. Hahn (194, 195) On Juniperus spp. (cult. juniper) (10, 15).

On Juniperus virginiana L. (10, 15, 194, 195, 207, 474). Ames:

Archer 1927 (Survey 522). Shenandoah: Wilson 1925.

Hahn (194, 195) reported successful inoculations with spores of this fungus, collected in Iowa, on *Cupressus glabra* Sudw. and *Thuja orientalis* L. The inoculations were made in Washington, D. C. but Anderson et al. (10) made this the basis for listing these plants as Iowa hosts. The present writers think such a basis unjustified.

441. Phomopsis lebiseyi (Sacc.) Died. (103)

On Acer sp. (cult. maple seedlings) (15). Shenandoah: Muncie and Bliss 1927 (Survey 802).

442. Phomopsis stewartii Peck. (473)

On Cosmos sp. (cult.) (15). Homestead: Archer and Haskell 1927 (Survey 1578).

On Cosmos bipinnatus Cav. Ames: Elmer 1924.

443. Phomopsis subordinaria (Desm.) Trav. (103)

On Plantago aristata Michx. Conesville: Archer 1927 (Survey 941). Exsic. cited: Krieger F. sax. 2137.

444. Phomopsis vexans (Sacc. & Syd.) Harter (206)

On Solanum melongena L. (cult. eggplant) (15). Muscatine: Porter 1920.

445. Phragmidium americanum Diet. (25, p. 167)

On Rosa sp. (cult.) (25, 31). Emmetsburg: Archer 1927 (Survey 1349). Shenandoah: Muncie and Archer 1926.

On Rosa blanda Ait. Winneshiek Co.: Goddard 1895.

On Rosa pratincola (arkansana) Greene (Rosa heliophila Greene). Forest City: Bakke 1913. Greenfield: Archer 1927 (Survey 1118).

446. Phragmidium andersoni Shear (25, p. 173 and p. 727)
On Potentilla fruticosa L. (Dasiphora fruticosa (L.) Ryd.) (25, 31).

Decorah: Holway 1885**.

447. Phragmidium disciflorum (Tode) James. (25, p. 171 and p. 727) On Rosa sp. (25, 31, 406). Iowa City: Hitchcock 1889**. On Rosa setigera Michx, Shenandoah: Wilson 1924.

448. Phragmidium imitans Arth. (25, p. 165)

On Rubus idaeus L. var. aculeatissimus (C. A. Meyer) Regel &

Tiling (16).

On Rubus strigosus Michx. (25, 31). Decorah: Holway 1882*, 1883*, 1884 (Ell. N. Amer. Fung. 1480), Ibid.*; 1884 (Barth. N. Amer. Ured. 518), Ibid.*; 1885 (Barth. N. Amer. Ured. 1124), Ibid*. Winneshiek Co.: Goddard 1895.

449. Phragmidium ivesiae Syd. (25, p. 174)

On Potentilla paradoxa Nutt. (25, 31). Spirit Lake: Arthur 1894 (Barth. N. Amer. Ured. 916).

Phragmidium mucronatum Amer. auct. = Phragmidium americanum

450. Phragmidium obtusum (Strs.) Wint. (25, p. 185)

Syn. Kuehneola obtusa (Strs.) Arth., Frommea obtusa (Strs.) Arth. On Potentilla canadensis L. (16, 25, 31, 522). Decorah: Holway 1887 (Barth. N. Amer. Ured. 715), Ibid.*, 1888**. Newton: Bertram 1886**. Winneshiek Co.: Goddard 1895.

451. Phragmidium rosae-arkansanae Diet. (25, p. 170)

On Rosa pratincola (arkansana) Greene (Rosa heliophila Greene) (31, 522). Ames: Carver 1892; Combs 1894; Stewart 1894. Decorah: Holway 1878*, 1885 (Barth. N. Amer. Ured. 1014), Ibid.*; 1885 (Barth. N. Amer. Ured. 914), Ibid.*. Winneshiek Co.: Goddard 1895.

452. Phragmidium rosae-setigerae Diet. (25, p. 167) On Rosa setigera Michx, Ames: Gilman 1924.

453. Phragmidium speciosum Cke. (25, p. 175)

Syn. Earlea speciosa (Fr.) Arth.

On Rosa sp. (20, 25, 341, 380, 383, 406). Ames: Carver 1896**.

Turin: Bessey 1871. Winneshiek Co.: Goddard 1895. Winterset: R. H. Porter 1927 (Survey 615).

On Rosa blanda Ait. (16, 25, 31, 53). Ames: Bessey 1878, 1882; McNeill 1882; Thomas 1878. Decorah: Holway 1879*, 1883 (Rabenh.—Wint. Fungi, Eur. 3707b)**; 1888**; Sac City: Linder—.

On Rosa pratincola (arkansana) Greene (Rosa heliophila Greene) (23, 25, 31). Spirit Lake: Arthur 1904**.

Phragmidium subcorticium Amer. auct. = Phragmidium speciosum.

454. Phragmidium uredinis Link. (25, p. 186 and 730)

Syn. Kuehneola uredinis (Lk.) Arth.

On Rubus allegheniensis Porter (25, 31)

455. Phyllachora graminis (Pers.) Fckl. (493)

On Agropyron repens (L.) Beauv. (352, 389). Indianola: Archer 1927 (Survey 1097).

On Bouteloua curtipendula (Michx.) Torr. (522).

On Elymus canadensis L. (8, 352, 368, 380). Ames: King 1910; Pammel 1909**.

On Elymus robustus Scribn. & Smith (389).

On Elymus virginicus L. Ames: Pammel 1897, 1909; Martin 1911; Halsted and Fairchild 1888 (Ell. & Ev. N. Amer. Fung. 2nd. Ser. 2127). Boone-Ledges: Anderson 1913. Clear Lake: Cratty 1918. Decorah: Holway 1879. Guthrie Center: Lennox 1925.

On Hystrix patula Moeneh. (352, 380, 389, 522). Ames: Carver 1892; Anderson 1913. Boone-Ledges: Archer 1927 (Survey 1578)**;

Blackwood 1903; Coe 1912.

On Muhlenbergia mexicana (L.) Trin. (380). Ames: Lummis 1901.

On Sorghastrum nutans (L.) Nash. (522).

On Triticum vulgare Vill. Ames: Bessey 1882.

456. Phyllachora haydeni (B. & C.) Dearn. (99)

Syn. Dothidea haydeni B. & C., Ophidothis haydeni Sacc.

On Aster sp. Grinnell: Conard 1923**.

On Aster lateriflorus (L.) Britt. (8). Decatur Co.: Anderson 1904.

On Aster salicifolius Lam. Grinnell: Conard 1923**.

On Solidago canadensis L. Conesville: Gilman 1927 (Survey 1493).

Exsic. cited: Barth. Fung. Col. 3042; Ell. & Ev. Fung. Col. 1332; Ravenel Fung. Carol. 59; Thüm. Myc. univ. 274.

The exact position of this fungus is uncertain. Atkinson (41) considers it to be the "conidial stage of an imperfect fungus——". Theissen and Sydow (493) designate it as "unreif". The Iowa collections contain the fusoid spores described by Atkinson and in addition there were present, in considerable quantity, minute, rod-shaped spores which measured approximately $3 \times 0.5\mu$. These were seen also in Fung. Col. 3042.

457. Phyllachora junci Fekl. (493)

On Juncus interior Wiegand (522).

458. Phyllachora lespedezae (Schw.) Sacc. (493)

On Lespedeza capitata Michx. (8, 522). Amana: Melhus 1924. Decatur Co.: Anderson 1904.

459. Phyllachora puncta (Schw.) C. R. Orton.

On Panicum agrostoides Muhl. Ames: Bettenga 1892.

This specimen was previously reported (189) as Phyllachora stenostoma Ell. & Tr. on Panicum dichtomiflorum Michx.

On Panicum dichotomum L. (352).

On Panicum scoparium Lam. (380).

On Panicum scribnerianum Nash. (389).

Exsic. cited: Kellerman, Ohio Fungi 51; Ell. & Ev. Fung. Col. 1752.

¹Fide-C. R. Orton.

Phyllachora trifolii (Pers.) Fckl. = Dothidella trifolii.

Phyllachora ulmi (Duv.) Fckl. = Dothidella ulmi.

460. Phyllachora vulgata Thiess. & Syd. (493) On Muhlenbergia sp. Ames: Pammel 1909¹.

On Muhlenbergia schreberi Gmel. Ames: King 1910¹.

On Muhlenbergia sobolifera (Muhl.) Trin. Ames: Carver 1892.

On Sporobolus brevifolius (Nutt.) Scribn. Ames: Bessey 1876. Rock Rapids: Pammel 1918.

461. Phyllactinia corylea (Pers.) Karst. (431)

On Acer saccharum Marsh. (7, 10, 522).

On Betula alba var. papyrifera (Marsh.) Spach. (7, 522).

On Carpinus caroliniana Walt. Ames: Carver 1892 (immature)

On Celastrus scandens L. (7). Ames: Morrison 1900 (conidia only).

On Cornus florida L. (7, 522)

On Cornus sanguinea L. Ames: Carver 1892.

On Cornus stolonifera Michx. (7, 171, 522).

On Cornus stricta Lam. Ames: Carver 1892.

On Corylus americana Walt. (7, 218, 522).

On Crataegus sp. (7, 10, 522.) Ames: Carver 1892; Hodson 1900.

On Crataegus tomentosa L. (7). Ames: Morrison 1900; Lummis 1901.

On Desmodium canadense (L.) DC. (7).

On Desmodium grandiflorum (Walt.) DC. (7, 522)

On Fraxinus sp. (7, 361, 522).

On Fraxinus americana L. (380, 522).

On Fraxinus pennsylvanica Marsh. var. lanceolata (Borkh.) Sarg. (7, 199). Ames: Carver 1895.

On Ostrya sp. Ames: Bessey 1877.

On Ostrya virginiana (Mill.) Koch. (7, 8). Ames: Thomas 1878. Decatur Co.: Anderson 1905. Steamboat Rock: Anderson 1913. Stratford: Anderson 1913.

On Quercus palustris Moench. (7).

On Quercus rubra L. (7).

On Quercus velutina Lam. (7). On Ulmus americana L. (7, 522).

On Ulmus racemosa Thomas (7, 8). Decatur Co.: Anderson 1905.

On Xanthoxylum americanum Mill. (7, 171, 522). Ames: Bessey 1878. Ossian: Lommen 1927.

462. Phyllosticta sp. (536)

On Arachis hypogaea L. (cult. peanut). Conesville: Layton 1928.

This is probably the *Phyllosticta sp.* and the *Phoma sp.* mentioned by Wolf (536). A specimen (*Phoma sp.*) in U. S. D. A. Herbarium collected by Archer in Missouri shows fruiting on both leaves and stems. Another specimen from Georgia on stems has been determined as the *Phoma melacna* (Fr.) Mont. & Dur. which is reported on various genera of the Leguminosae. (Cfr. Saccardo (428, v. 3, p. 136); Diedicke (103, v. 9, p. 120)). In the Iowa material the spots are pale brown, with reddish border, 2-9 mm. diam. Pycnidia black, epiphyllous, 15-30 μ diam. Spores hyaline, eguttulate 4-8 x 2.5-3 μ .

¹Fide-C. R. Orton.

463. Phyllosticta sp.

On Ludvigia polycarpa S. & P. (199).

464. Phyllosticta sp.

On Pyrus floribunda atropurpurea Hort. (cult. purple crab). Shenandoah: Muncie and Archer 1926**.

465. Phyllosticta abortiva E. & K. (157)

On Menispermum canadense L. (199). Ledges-Boone: Archer 1927 (Survey 1577).

In the original description by Ellis and Kellerman (157) the spores were said to be imperfectly developed. In the Iowa collection they were well developed in some of the pycnidia. They were hyaline, bacillar, and measured $3-4 \times 1\mu$.

Phyllosticta aesculicola Sacc. = Guignardia aesculi,

Phyllosticta ampelopsidis E. & M. = Guignardia bidwellii.

Phyllosticta antennariae E. & E.

The specimen reported under this name by Anderson (8) is found to be an immature fungus occurring on overwintered leaves.

466. Phyllosticta apocyni Trel. (501)

On Apocynum androsaemifolium L. (522).

467. Phyllosticta batatas Cke. (446) On Ipomoea batatas Lam. (208).

Phyllosticta convallariae Pers. — Sphaeropsis cruenta.

Phyllosticta cornicola Rabh. = Phyllosticta globifera. 468. Phyllosticta corvli West. (446)

On Corylus americana Walt. (522).

Phyllosticta cruenta Kickx. — Sphaeropsis cruenta.

469. Phyllosticta decidua Ell. & Kellerm. (446)

On Humulus lupulus L. (125).

On Lycopus rubellus Moench. (522)

On Mentha arvensis var. canadensis (L.) Briquet. (522).

470. Phyllosticta desmodii E. & E. (139)

On Desmodium canadense (L.) DC. Conesville: Archer 1927 (Survey 977).

471. Phyllosticta destruens Desm. (151) On Prunus virginiana L. (150).

472. Phyllosticta deutziae E. & E. (446)

On Deutzia scabra candidissima Hort. (snowflake deutzia). Shenandoah: Muncie & Archer 1926**.

473. Phyllosticta discincta Davis (88)
On Uvularia grandiflora Smith (522)

474. Phyllosticta fatiscens Pk. (446) On Nymphaea advena Ait. (522).

Phyllosticta fraxini E. & M. = Cylindrosporium fraxini.

475. Phyllosticta gallicola E. & E. (446)

On Solidago latifolia L. Ft. Dodge: Archer 1927 (Survey 1199).

476. Phyllosticta gentianaecola (DC.) E. &. E. (446) On Gentiana andrewsii Griseb, (522).

On Gentiana flavida Gray (199)

477. Phyllosticta globifera E. & E. (326) On Cornus amomum Mill. (496). 478. Phyllosticta grossulariae Sacc. (446)

On Ribes gracile Michx. (522).

479. Phyllosticta humuli Sacc. & Speg. (446)

On Humulus sp. (139, 428).

On Humulus lupulus L. (139, 150, 446).

Phyllosticta labruscae — Guignardia bidwellii

480. Phyllosticta lychnidis (Fr.) E. & E. (446)

On Lychnis coronaria Desr. (cult. rose campion) (15). Shenandoah: Bliss (Survey 1659)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 2839; Seymour & Earle Econ. Fungi 262.

The fungus agrees with the specimen in the Ames packet of N. Amer. Fungi 2839, which had well developed pycnidia and spores. This is contrary to the statement of Ellis & Everhart (150, p. 59), also Seaver (446, p. 84). The Shenandoah collection had spores which were rod-shaped to oval, mostly straight, hyaline, 4-10 x 2-5 μ . Lind (292, p. 407) cites P. lycnidis with spores 5-6 x 1 μ on Melandrum noctiflorum. The Survey 1659 is indistinguishable from Phyllosticta pallida Halsted (Seym. & Earle Econ. Fungi 262). The original description of the latter states that the spores are 4-7 x 1.5-2 μ but an examination of the type reveals that they are 4-7 x 1.5-3.4 μ . In addition, scattered Septoria spores are found in some of the pycnidia. This was true likewise of the Iowa collection and the same fact has been reported also by Allescher (5, p. 148) for P. zahl-bruckneri Bäum. This evidence doubtlessly indicates a relationship between the species of Phyllosticta and Septoria occurring on these hosts.

The numerous species of Septoria and Phyllosticta reported on various members of the Caryophyllaceae are slightly or not at all distinguished one from the other. The synonomy of these fungi can be cleared up only by extensive culture and infection studies.

481. Phyllosticta melaleuca E. &. E. (446) On Ulmus americana L. (10, 522).

482. Phyllosticta minima (B. & C.) Ell. & Ev. (150)

On Acer saccharinum L. Ames: Blackwood 1903. Decatur Co.: Anderson 1904.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 534; Ell. & Ev. Fung. Col. 660.

The specimen collected by Anderson was reported (8) as Septoria salliae W. R.

Phyllosticta minutissima E. & E. = Septoria aceris.

Phyllosticta paviae Desm. = Guignardia aesculi.

483. Phyllosticta phaseolina Sacc. (446)

On Strophostyles helveola (L.) Britton (199). Conesville: Layton 1927 (Survey 1485).

On Vigna sinensis Endl. Conesville: Layton 1928.

Exsic. cited: Barth. Fung. Col. 2136.

484. Phyllosticta phomiformis Sacc. (446)

On Quercus alba L. (199). Ledges-Boone: Coe 1912. On Quercus macrocarpa Michx. Ames: Gilman 1923.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1160; Ell. & Ev. Fung. Col. 274; Seymour & Earle Ec. Fung. 181.

485. Phyllosticta prunicola (Op.) Sacc. (4, 150, 435, 446)

On Prunus sp. (cult. plum) (15). Ames: Archer 1927 (Survey 1409). Decorah: Archer 1927 (Survey 1464). Mondamin: Archer 1927 (Survey 1254)**. Osage: Archer 1927 (Survey 1400).

On Prunus americana Marsh. Menlo: Archer 1927 (Survey 1130).

Waverly: Archer 1927 (Survey 1457).

On Prunus padus L. Ames: Carver 1892.

On Prunus pennsylvanica L. (502). Ames: Hume 1899 (immature). On Prunus serotina Ehrh. Ft Dodge: Archer 1927 (Survey 1211).

Exsic. cited: P. prunicola: Barth. Fung. Col. 3543, 4047; Bri. & Cav. F. Para, 141. P. circumscissa: Ell N. Amer. Fung. 481; Barth. Fung. Col. 3353. P. serotina: Ravenel, Fung. Amer. 513; Barth. Fung. Col. 2252.

In the cited Iowa specimens both on plum and cherry, the spores were oblong-ellipsoid, usually with an elongated vacuole at center, olivaceous, 5-7 x 2-3.4 μ . In younger stages the spores were hyaline, rather irregular in size and shape and correspond after a fashion to the spores obtained in

culture by Schwarze (435).

Seaver (446, p. 25), Ellis & Everhart (150) and others consider the form on cherry to be distinct but examination of the material in Fung. Col. 3353, N. Amer. Fung. 841, Raverel, Fung. am. 513, Fung. Col. 2252, 3646, 4047 showed that these did not differ in any respect from the form on the plum. This, of course, agrees with the conclusions of Aderhold (4, p. 782-94).

486. Phyllosticta rubra Pk. (150, 446)

On Crataegus oxyacantha L. (cult. English haw) (15). Shenandoah: Muncie and Archer 1926 (Survey 1660); Bliss 1927 (Survey 1661).

Exsic. cited: Rav. F. Am. 576.

The two Iowa collections are nearer $P.\ rubra$ Pk. than they are to either $P.\ grisea$ Pk. or $P.\ crataegi$ (Cooke) Sacc. However in the original description of $P.\ rubra$ the pycnidia are said to be epiphyllous and the spores to be $8 \times 6\mu$. In the Iowa material the pycnidia are amphigenous, and the spores $6.8\text{-}10 \times 6\text{-}6.8\mu$ (mostly $9 \times 6.8\mu$).

487. Phyllosticta rudbeckiae E. & E. (146)

On Rudbeckia laciniata (10, 522). Indianola: Archer 1927 (Survey 1070).

In the original description (146, p. 430) the spores are said to be 8-12 x 2.5μ . In the Iowa collection they were 9-14 x $3-4\mu$. Many showed an oil globule in either end and a few showed a suggestion of a cross wall.

488. Phyllosticta saccharina E. & M. (446)

On Acer saccharum L. Decatur Co: Anderson 1903.

On Acer saccharum var. nigrum (Michx.) Britton (8).

Phyllosticta smilacina Dearn. - Sphaeropsis cruenta

489. Phyllosticta solitaria E. & E. (438)

On Pyrus malus L. (apple) (15, 191). Ames: Anderson 1913.

490. Phyllosticta sorbi West. (428, v. 3, p. 8)

On Sorbus americana Marsh. (cult. mountain ash). Ames: Carver 1892.

On Sorbus aucuparia L. (cult. European mountain ash) (15). Osage: Archer 1927 (Survey 1380a, b, c). Shenandoah: Muncie and Archer 1926 (Survey 1680).

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1726.

In the example examined of N. Amer. Fung. 1726 the host is Sorbus aucuparia and not Sorbus (Pyrus) americana as labeled. In the scanty material of the packet there were found spores of both Septoria aucupariae Bres. and Phyllosticta sorbi West.

The Iowa collection, especially 1380 a and b, have only sterile pycnidia. These two collections are identical with the Krieger F. sax. 795b issue of Septoria aucupariae Bres.

(See under Mycosphaerella aucupariae p. 361.)

Phyllosticta sphaeropsoidae E. & E. = Guignardia aesculi.

491. Phyllosticta straminella Bres. (469)

On Rheum rhaponticum L. (cult. rhubarb) (15). Shenandoah: Bliss 1927 (Survey 1624).

492. Phyllosticta teucrii Sacc. & Speg. (428, v. 3, p. 49) On Teucrium canadense L. (199).

493. Phyllosticta toxica Ell. & Mart. (304)

On Rhus toxicodendron L. (150; 304; 428, v. 3, p. 17; 446). Decorah: Holway 1882 (Ell. N. Amer. Fung. 1162).

494. Phyllosticta violae Desm. (246, 446)

On Viola sp. (522). Ruthven: Archer 1927 (Survey 722)

On Viola obliqua Hill. Decatur Co.: Anderson 1905.

On Viola pubescens Ait. (10, 199, 446).

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1371; Bri. & Cav. F. Para. 391.

495. Phyllosticta virginiana (Ell. & Halst.) Seaver (446)

On Prunus sp. (cult. plum) (15). Griswold: Archer 1927 (Survey 1583).

On Prunus sp. (cult. Hansen var.). Shenandoah: Muncie & Archer 1926**.

On Prunus serotina Ehrh. (10, 446).

On Prunus virginiana L. (10, 446).

Exsic. cited: Ell. & Ev. N. Amer. Fung. 26, 76, 2830; Barth. Fung. Col. 2135, 4836; U. S. D. A. 347, 1164.

Phyllosticta viridis E. & K. = Cylindrosporium fraxini.

Phyllosticta viticola Sacc. & Speg. = Guignardia bidwellii.

496. Phyllosticta vulgaris Desm. (446) On Prunus virginiana L. (150).

497. Phyllosticta zonata E. & E. (446)

On Pyrus ioensis Bailey (10, 149, 150, 446). Ames: Hume 1899 (Ell. & Ev. Fung. Col. 1444); Archer 1927 (Survey 1152).

The pycnidia and spores of this fungus cannot be distinguished from those of *Phyllosticta prunicola* (see page 375) on various species of Prunus. 498. Physalospora arthuriana Sacc. (428, v. 9, p. 596)

¹Halsted (199) reported this fungus from Iowa but failed to list the host. Saccardo (428, v. 3, p. 49) lists *Phyllosticta teucrii* from Italy. Seaver (446, p. 61) lists the Phyllosticta on *Teucrium canadense* in the United States as *P. decidua* with a range that includes Iowa.

On Iva xanthifolia Nutt. Charles City: Arthur 1882 (Ell. & Ev. N. Amer. Fung. 2nd. Ser. 1665).

Physalospora bidwellii (Ell.) Sacc. — Guignardia bidwellii, Physalospora cydoniae Arnaud — Physalospora malorum.

499. Physalospora malorum (Pk.) Shear (450)

Syn. Sphaeropsis malorum Pk.

On Crataegus monogyna Jacq. Ames: Muncie 1927 (Survey 1160).

On Pyrus malus L. (cult. apple) (15, 191). Boone: Coe 1912. Hedrick: Hinds 1908**.

500. Physoderma zeae-maydis Shaw. (498)

On Zea mays L. Ontario: R. H. Porter 1928.

501. Phytophthora cactorum (L. & C.) Schröt. (426) On Panax quinquefolia L. (cult. ginseng) (10, 15, 410).

502. Phytophthora infestans (Mont.) DeBy. (264)

On Solanum tuberosum L. (potato) (8, 15, 83, 165, 191, 202, 299, 376, 383, 410, 520). Ames: Buchanan 1903; Blackwood 1903. Decorah: Holway 1884.

Phytophthora omnivora DeBy. = Phytophthora cactorum.

Piggotia fraxini B. & C. = Cylindrosporium fraxini.

Pileolaria toxicodendri (B. & R.) Arth. = Uromyces toxicodendri.

503. Piricularia grisea (Cke.) Sacc. (468)

On Digitaria sanguinalis (L.) Scop. (8, 384, 389). Ames: Carver 1892; Stewart 1893. Conesville: Layton 1927 (Survey 1511)**. Decatur Co.: Anderson 1904. Grinnell: Conard 1923**.

On Setaria glauca (L.) Beauv. (384). On Setaria italica (L.) Beauv. (10).

On Setaria viridis (L.) Beauv. (384). Ames: Pammel 1909**. Muscatine: Layton 1927 (Survey 1486). Shenandoah: Bliss 1927 (Survey 1167).

Exsic cited: Ell. & Ev. Fung. Col. 295, 882; Barth. Fung. Col. 2255, 3247; Ell. & Ev. N. Amer. Fung. 374; Seymour & Earle Ec. Fung. 61, 62.

504. Piricularia parasitica Ell. & Ev. (144)

On Phyllachora graminis (Pers.) Fckl. (8).

505. Plasmodiophora brassicae Wor. (70)

On Brassica oleracea var. capitata L. (167, 191).

506. Plasmopara australis (Speg.) Swingle (520)
 On Echinocystis lobata (Michx.) T. & G. (299, 410, 522). Decatur
 Co.: Anderson 1904. Decorah: Holway 1884, 1885**.

Plasmopara cubensis (B. & C.) Humphrey = Pseudoperonospora cubensis.

507. Plasmopara geranii (Pk.) B. & DeT. (520)

On Geranium carolinianum L. (202, 299, 410). On Geranium maculatum L. (54, 202, 299, 410, 522). Ames: Melhus

508. Plasmopara gonoboli (Lagerh.) Swingle (520)

On Gonobolus laevis Michx. (8, 410). Decatur Co.: Anderson 1902.

509. Plasmopara halstedii (Farl.) B. & DeT. (520)

On Ambrosia artemisiifolia L. (299, 410, 520, 522).

On Ambrosia trifida L. (299, 410, 522). Iowa City: Hitchcock 1887**. Vail: Archer 1927 (Survey 1244).

On Bidens cernua L. (299, 410). Galt: Archer 1927 (Survey 1223).

On Bidens comosa (Gray) Wiegand (202, 522). On Bidens connata Muhl. (202, 229, 410). Sheldahl: Pammel 1898.

On Bidens frondosa L. (299, 410, 520, 522). Ames: Ball 1900: Bessey 1878: Wright 1892.

On Bidens laevis (L.) BSP. (B. chrysanthemoides) (202, 299, 410, 520). Ames: Bessey 1878.

On Bidens vulgata Greene. Garner: Archer 1927 (Survey 1370).

On Centaurea sp. (380).

On Erigeron sp. (410, 483). Decorah: Holway 1884.

On Eupatorium purpureum L. (410, 520, 522). Ames: Bessey 1879 (?) (Ell. N. Amer. Fung. 209).

On Helianthus sp. Ames: Halsted 1885**.

On Helianthus annuus L. (10, 366, 368, 410).

On Helianthus doronicoides Lam. (299, 410, 520, 522).

On Helianthus grosse-serratus Martens (197, 299, 366, 410, 520). Clarion: Melhus 1909**. Oelwein: Archer 1927 (Survey 567).

On Helianthus maximiliani Schrad. (410, 520). New Valley: Pammel 1902.

On Helianthus tuberosus Schrad. (368, 410).

On Lepachys pinnata T. & G. (522). Fayette: Wilson 1909 (Wilson & Seaver Ascom. & Low. Fung. 95).

On Rudbeckia laciniata L. (15, 54, 299, 522). Ames: Melhus 1916. Decorah: Holway 1884.

On Rudbeckia triloba (54, 299, 410). Decorah: Holway 1884.

On Silphium laciniatum L. (410, 520).

On Silphium perfoliatum L. (299, 410, 520). Lamoni: Melhus 1912**.

On Xanthium canadense Mill. (410).

510. Plasmopara obducens Schröt. (520)

On Impatiens sp. Ames: Gilman 1928 (Survey 1714). Decorah: Holway 1880.

On Impatiens biflora Walt. (54, 410, 522).

On Impatiens pallida Nutt. (Impatiens aurea) (299, 410, 520, 522). Decorah: Holway 1884**.

511. Plasmopara pygmea (Unger) Schröt. (172)

On Anemone sp. (202, 410).

On Anemone canadensis L. (Anemone dichotoma L.) (54, 299, 410, 522). Ames: Halsted 1885**; Hitchcock 1885-6; King 1911; Pammel 1910.

On Anemone caroliniana L. (54, 522, 530). Fayette: Wilson 1908 (Wilson & Seaver Ascom. & Low. Fung. 66).

On Anemone guinquefolia L. (Anemone nemorosa L.) (522). Decorah: Holway 1880. Fayette: Wilson 1909 (Wilson & Seaver Ascom, & Low. Fung. 93).

On Hepatica acutiloba DC. (522), Ledges-Boone: Archer 1927 (Survev 634).

512. Plasmopara viticola (B. & C.) B. & DeT. (520)

On Psedera quinquefolia (L.) Greene (10, 410).

On Vitis sp. (54, 363, 376). Ames: Buchanan 1903**; Snyder 1896**. Boone: Orton 1908**. Decorah: Holway 1880.

On Vitis sp. (cult.) (10, 15, 406). Ames: Seyder 1906. Conesville: Archer 1927 (Survey 960)**. Grinnell: Conard 1921**. West Union: Pammel 1908**.

On Vitis bicolor LeConte (410).

On Vitis labrusca L. (8, 383, 410, 520). Ames: Carver 1896**; Crane 1896; King 1912; Pammel 1902; Raymond 1891; Rolfs 1891; Stewart 1893. Decatur Co.: Anderson 1902.

On Vitis labruscana Bailey (grape) (368),

- On Vitis riparia L. (299). Ames: Seyder 1906. Boone: Carver 1896**.
- On Vitis vulpina L. (197, 202, 366, 377, 410, 520, 522, 530). Ames: Archer 1927 (Survey 801)**; Bakke 1907. Fayette: Wilson 1909 (Wilson & Seaver Ascom. & Low. Fungi 68).

513. Plectodiscella veneta (Speg.) Burkh. (63)

Syn. Gloeosporium venetum Speg.

On Rubus sp. Ames: Buchanan 1903**.

On Rubus spp. (cult. blackberry) (15, 191, 340).

On Rubus spp. (cult. raspberry) (15, 191, 341). Ames: Hodson and Hume 1899. Lyons: Fleming 1901. Mason City: Pammel 1908. Milford: Northey 1908.

On Rubus allegheniensis Porter (blackberry) (8).

On Rubus idaeus L. var. aculeatissimus (C. A. Meyer) Regel & Tiling. (8).

On Rubus neglectus Pk. (8).

On Rubus occidentalis L. (8, 383). Boone: Anderson 1913.

514. Plenodomus destruens Harter (205) On Ipomoea batatas Lam. (10, 207, 208).

515. Pleonectria berolinensis Sacc. (108, 444)

On Ribes sp. Decorah: Holway 1882, 1892 (Ell. & Ev. Fung. Col. 619). This fungus occurs on dead canes of Ribes sp. but has been thought to cause a serious cane blight. Inoculation experiments by Durand (108) were negative, however.

516. Pleosphaerulina briosiana Poll. (325) On Medicago sativa L. (10, 325).

517. Pleurotus ulmarius Bull. (268)

On Acer negundo L. (10, 406).

On *Ulmus sp.* (406).

518. Plowrightia morbosa (Schw.) Sacc. (435)

On Prunus spp. (cult. plum) (15, 380, 406). Osage: Archer 1927 (Survey 1374)**.

On Prunus americana L. (8, 53, 361, 368, 376, 380, 383, 406, 522).

Decatur Co.: Anderson 1900. Decorah: Holway 1883. LedgesBoone: Coe 1912.

On Prunus armeniaca L. (361).

On Prunus domestica L. (8, 361, 368, 380). Ames: Stewart 1893.

On Prunus instititia L. Lamoni: Anderson 1913.

On Prunus padus L. (380). Ames: Lummis 1901. Calamus: Fitch 1913.

On Prunus serotina Ehrh. (361, 368, 377).

On Prunus virginiana L. (8, 361, 376, 380, 522). Forest City: Bakke 1911.

The name Dibotryon has been suggested by Thiessen and Sydow (493, p. 663) for the name of the genus Plowrightia in the case of *P. morbosa* but the authors have retained the old name because of its common usage.

519. Plowrightia ribesia (Pers.) Sacc. (428, v. 2, p. 635) On Ribes grossularia L. Decorah: Holway 1892.

520. Podosphaera leucotricha (Ell. & Ev.) Salm. (431)

On Pyrus malus L. (7, 8, 53, 171, 341, 363, 364, 368, 380, 383, 406, 522). Ames: Combs 1894; Carver 1894, 1895 (conidia only); Anderson 1913; Pammel 1894 (Ell. & Ev. N. Amer. Fung. 3213). Lamoni: Anderson 1911.

On Pyrus sieboldi Regel (Pyrus toringo) (Toringo crab) (380).

 $Podosphaera\ minor\ E.\ C.\ Howe = Podosphaera\ oxyacanthae.$

521. Podosphaera oxyacanthae (DC.) DeBy. (431)

On Crataegus sp. Ames: Hitchcock 1899. Union: Anderson 1913.

On Crataegus coccinea L. (7).

On Crataegus mollis (T. & G.) Scheele (380).

On Crataegus punctata Jacq. (7, 380).

On Crataegus tomentosa L. (7).

On Prunus sp. (cherry). Ames: Halsted 1885**. Lisbon: Biddle 1909**.

On Prunus spp. (cult. cherry) (15, 340, 406).

On Prunus spp. (cult. plum) (7, 15, 342, 406, 522). Osage: Archer 1927 (Survey 1398).

On Prunus angustifolia Marsh. Ames: Bettenga 1892.

On Prunus armeniaca L. (cult. apricot) (15). Shenandoah: Muncie and Archer 1927 (Survey 1625).

On Prunus avium L. (7, 8, 10, 522). Ames: Rolfs 1891.

On Prunus besseyi Bailey (cult. sand cherry; Rocky Mt. dwarf cherry) (7, 8, 15). Shenandoah: Bliss 1927 (Survey 1011).

On Prunus cerasus L. (cherry) (7, 8, 53, 171, 191, 193, 341, 355, 357, 359, 362, 380, 383, 406). Ames: Bessey 1877; Carver 1892; Crane 1896; Fox 1909; Hodson 1900; Hume 1899; Raymond 1891 (conidia only); Sexton 1894 (conidia only); Stewart 1894; Walker 1899. Atlantic: Ness 1908. Boone-Ledges: Anderson 1913; Coe 1912. Council Bluffs: Anderson 1912. Decatur Co.: Anderson 1905. Hamburg: Mincer 1912**. Lamoni: Anderson 1913. Lohrville: Middleton 1902. Sac City: Pammel 1908**. Shenandoah: Anderson 1913.

On Prunus persica L. (peach) (406).

On Prunus pumila L. (380). Ames: Carver 1892, 1894; Sexton 1894.

On Prunus tomentosa Thunb. (cult. Nanking cherry). (15.) Shenandoah: Bliss 1927 (Survey 1658).

On Pyrus malus L. (53, 341, 364).

On Sanguisorba canadensis L. (7).

On Spiraea salicifolia L. (199).

522. Polyspora sp. (306)

On Rosa sp. (cult.). Ames: Archer 1927 (Survey 1305).

Polythelis thalictri (Chev.) Arth. - Puccinia thalictri.

Polythrincium trifolii K. - Dothidella trifolii.

523. Poria purpurea Fr. (428, v. 6, p. 319) On Juniperus virginiana L. (10, 342).

524. Pseudomonas andropogoni EFS. (118)

Syn. Bacterium andropogoni EFS.

On Holcus halepensis L. (Johnson grass) (366, 380).

On Holcus sorghum L. (cult. sorghum) (15, 191, 341, 352, 366, 368, 376, 380, 383, 406). Ames: Carver 1892; Combs 1894; Clapper 1908; Pammel 1908; 1909**.

525. Pseudomonas campestris (Pam.) EFS. (456)

Syn, Bacillus campestris.

On Brassica campestris L. (Brassica napobrassica Mill.) (cult. rutabaga) (10, 15, 368, 369, 406).

On Brassica oleracea var. capitata L. (cult. cabbage) (8, 15, 191, 341, 342, 376, 383, 406).

On Brassica rapa L. (cult. turnip) (15, 340, 406).

526. Pseudomonas campestris var. armoraciae McCulloch (302) Syn. Bacterium campestre var. armoraciae McC.

On Radicula armoracia (L.) Robinson, (cult. horseradish) (302).

527. Pseudomonas cannae Bryan (58) Syn, Bacterium cannae Bryan.

On Canna spp. (cult.). Shenandoah: Bliss 1927 (Survey 1708). 528. Pseudomonas coronafaciens Elliott (115) Syn, Bacterium coronafaciens Elliott,

On Avena sativa L. (cult. oats) (15, 191, 406). Fayette Co.: Archer 1927 (Survey 750).

529. Pseudomonas coronafaciens var. atropurpurea Reddy and Godkin (417)

Syn. Bacterium coronafaciens atropurpureum Reddy and Godkin.

On Agropyron repens (L.) Beauv. (quack grass) (15), Ames: Reddy 1929.

On Bromus inermis Leyss. Ames: Reddy 1929.

530. Pseudomonas delphinii (EFS.) Brvan (59)

Syn. Bacterium delphinii (EFS.) Bryan, Bacillus delphinii EFS.

On Delphinium sp. (cult.) (15, 406). Shenandoah: Muncie and Archer 1926 (Survey 1636).

On Delphinium sp. (English hybrid) (15). Des Moines: Nichols 1927 (Survey 655).

On Delphinium belladonna Hort. (cult.) (15).

531. Pseudomonas holci Kendrick (278)

On Holcus halepensis L. (278).

On Holcus sorghum L. (sorghum) (15, 278). Story City: Archer 1927 (Survey 1341).

On Holcus sorghum sudanensis Bailey (cult. sudan grass) (15, 278). Shenandoah: Bliss 1927 (Survey 1170).

On Holcus sorghum technicus Bailey (278).

On Pennisetum glaucum (L.) R. Br. (278).

On Setaria glauca (L.) Beauv. (278). Des Moines: Archer 1927 (Survey 1046). Mondamin: Archer 1927 (Survey 1267). Shenandoah: Bliss 1927 (Survey 1526).

On Zea mays L. (278).

On Zea mays var. indentata Bailey (corn) (15, 278).

532. Pseudomonas lachrymans EFS, and Bryan (460)

Syn. Bacterium lachrymans EFS. and Bryan.

On Cucumis sativus L. (cult. cucumber) (15, 406).

533. Pseudomonas marginata McC. (300)

Syn, Bacterium marginatum McC.

On Gladiolus sp. (15). Ames: Evans 1928.

534. Pseudomonas medicaginis Sack. (430)

Syn. Bacterium medicaginis (Sack.) EFS.

On Medicago sativa L. (cult. alfalfa) (15, 406). Atlantic: Archer 1927 (Survey 1582). Scranton: Archer 1927 (Survey 1593).

535. Pseudomonas mori B. & L. (455)

Syn, Bacterium mori (B. & L.) EFS.

On Morus sp. (mulberry) (15) On Morus alba tartarica Loudon (cult. Russian mulberry) (15). Shenandoah: Bliss 1927 (Survey 1531); Muncie and Archer 1927 (Survey 1560).

536. Pseudomonas phaseoli EFS. (329)

Syn. Bacterium phaseoli EFS.

On Phaseolus vulgaris L. (cult. bean) (15, 191, 406).

537. Pseudomonas phaseoli var. sojensis Hedges (215)

Syn. Bacterium phaseoli sojense Hedges.

On Soja max Piper (cult. soybean) (15). Shenandoah: Bliss 1927 (Survey 1142). Waverly: Archer 1927 (Survey 1449).

538. Pseudomonas pruni EFS. (424)

Syn. Bacterium pruni EFS.

On Prunus sp. (cult. cherry) (15).

On Prunus sp. (cult. Rocky Mountain dwarf cherry) (15). Shenandoah: Bliss 1927 (Survey 1620).

On Prunus sp. (cult. plum) (15). Homestead: Archer and Haskell 1927 (Survey 1580).

On Prunus americana Marsh. Decatur Co.: Anderson 19021.

On Prunus armeniaca L. (Alexis apricot) (15). Shenandoah: Bliss 1927 (Survey 1618).

On Prunus besseyi Bailey (15). Ames: Anderson 19131.

On Prunus cerasus L. (Montmorency cherry). Mondamin: Archer 1927 (Survey 1252).

On Prunus domestica L. (cult. German prune) (15). Shenandoah: Bliss 1927 (Survey 1619),

On Prunus munsoniana Wight & Hedr. (Wildgoose plum). Sac City: Archer and Layton 1927 (Survey 702).

On Prunus persica (L.) Stokes (Amygdalus persica L.) (cult. peach) (15, 406). Des Moines: Pammel 1915. Murray: Ness 1908. Shenandoah: Bliss 1927 (Survey 1037).

539. Pseudomonas solanacearum EFS. (458)

Svn. Bacillus solanacearum EFS.

On Solanum tuberosum L. (cult. potato) (15, 340, 383, 406).

Originally (8, 189) these specimens were reported as Cylindrosporium padi Karst. Recent examination has shown the lesions on them to be bacterial rather than fungous in origin.

540. Pseudomonas striaefaciens Elliott (117)

Svn. Bacterium striaefaciens Elliott.

On Avena sativa L. (oats) (15). Hastings: Reddy 1927 (Survey 1609). Rockwell City: Archer 1927 (Survey 694).

541. Pseudomonas translucens Jones et al. (265)

Svn. Bacterium translucens Jones et al.

On Hordeum vulgare L. (barley) (15, 191, 406).

542. Pseudomonas translucens var. undulosa S. J. and R. (461) Syn. Bacterium translucens var. undulosum S. J. & R. On Triticum vulgare Vill. (wheat) (15, 191, 406).

543. Pseudomonas trifoliorum Jones et al. (267)

Syn. Bacterium trifoliorum Jones et al.

On Trifolium incarnatum L. (10).

On Trifolium medium L. (10).

On Trifolium pratense L. (red clover) (10, 15). Lytton: Archer 1927 (Survey 563). Oelwein: Archer 1927 (Survey 696). On Trifolium repens L. (10).

544. Pseudomonas tumefaciens (EFS, & Towns,) Duggar (459)

On Populus alba var. pyramidalis Bunge (cult. bolleana poplar) (15).

On Prunus sp. (8).

On Prunus persica (L.) Stokes (cult. peach) (8, 332).

On Purus sp. (8).

On Pyrus malus L. (cult, apple) (8, 15, 320, 332, 376).

On Rheum rhaponticum L. (rhubarb). Shenandoah: Muncie 1929.

On Rosa sp. (cult. rose) (8, 15, 406).

On Rubus sp. (Cumberland black raspberry) (8, 15, 191). Waterloo: 1914.

On Rubus sp. (cult. raspberry) (8, 317, 339, 406).

On Rumex crispus L. (333).

On Vitis sp. (cult. grape) (8, 213).

545. Pseudomonas vesicatoria Doidge (182) Syn. Bacterium vesicatorium Doidge.

On Lycopersicon esculentum Mill. (tomato) (10, 15, 182).

546. Pseudoperonospora cubensis (B. & C.) Rostow. (427)

On Cucumis melo L. (406). Conesville: Layton 1928.

On Echinocystis lobata (Michx.) T. & G. (8).

On Momordica balsamina L. (410, 520).

547. Pseudopeziza medicaginis (Lib.) Sacc. (257)

On Medicago sativa L. (alfalfa) (15, 77, 191, 352, 376, 383, 406).

Ames: Pammel 1890 (Seym. & Earle Ec. Fung. 506); 1909**;

King 1912. Clarion: Melhus 1909**. Earlham: DeVault 1915.

Farragut: Plase 1909**. Pocahontas: McIntire 1915. Selma:

Anderson 1915. Shenandoah: Field 1909.

548. Pseudopeziza populi-alba Kleb. (286)

Syn. Marssonina populi (Lib.) Sacc.

On Populus spp. (cult. poplar) (15).

On Populus alba L. Ames: Anderson 1913.

On Populus alba nivea Hort. Ames: Patel 1927 (Survey 1042). Shenandoah: Bliss 1927 (Survey 1020).

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1172; Ell. & Ev. Fung. Col. 292, 588; Krieger, F. sax 2242.

549. Pseudopeziza ribis (Lib.) Kleb. (435)

Syn. Gloeosporium ribis (Lib.) M. & D.

On Ribes sp. (wild current) (15).

On Ribes floridum L'Her. Story City: Archer 1927 (Survey 679).

On Ribes gracile Michx. Ames: Diehl 1915. Decatur Co.: Anderson 1904. Glenwood: Archer 1927 (Survey 869). Indianola: Archer 1927 (Survey 1081). Ledges-Boone: Coe 1914.

On Ribes grossularia L. (cult. gooseberry) (15, 406). Ames: Hill 1907; King 1909. Ledges-Boone: Coe 1914. Perry: Reddy 1927 (Survey 1035)**.

On Ribes vulgare Lam. (Ribes rubrum) (cult. currant) (15, 361, 406). Ames: King 1909**. Harper's Ferry: Pannel 1906.

New Hampton: Archer 1927 (Survey 1441).

550. Pseudopeziza trifolii (Biv.) Fekl.

On Trifolium pratense L. (red clover) (406)

551. Puccinia absinthii (Hedw.) DC. (25, p. 508)

Syn. Bullaria absinthii (Hedw.) Arth. & Mains.

On Artemisia dracunculoides Pursh. (16, 25, 31, 199). Ames: Halsted 1887 (Ell. & Ev. N. Amer. Fung. 2nd Ser. 2250), Ibid.*.

On Artemisia ludoviciana Nutt. (16, 25, 31). Decorah: Holway 1879*, 1885**, 1888**.

On Artemisia serrata Nutt. (25, 31). Decorah: Holway 1885 (Barth. N. Amer. Ured. 1020), Ibid.*; 1885 (Barth. N. Amer. Ured. 1021), Ibid.*.

552. Puccinia abundans (Peck) Jackson (25, p. 328)

Syn. Dicaeoma abundans (Peck) Arthur and Fromme.

On Symphoricarpos orbiculatus Moench. Decatur Co.: Anderson 1904.

553. Puccinia acetosae (Schum.) Körn. (25, p. 385)

Syn. Dicaeoma acetosae (Schum.) Kuntze.

On Rumex altissimus Wood. Indianola: Archer 1927 (Survey 1100)

On Rumex britannica L. Vail: Archer 1927 (Survey 1240)

Arthur (25) does not report this fungus on Rumex britannica L.

Puccinia agropyri E. & E. = Puccinia clematidis Puccinia albiperida Arth, = Puccinia grossulariae

554. Puccinia ambigua (Alb. & Schw.) Lagerh. (25, p. 473)

Syn. Allodus ambigua (A. & S.) Arth.

On Galium aparine L. (16, 25, 31). Decorah: Holway 1901**; 1902**. Winneshiek Co.: Goddard 1895.

Puccinia amorphae M. A. Curt. = Uropyxis amorphae

555. Puccinia andropogi Schw. (25, p. 281)

Syn. Dicaeoma andropogonis (Schw.) Kuntze.

On Andropogon sp. Ames: Raymond 1891.

On Andropogon furcatus Muhl. (16, 25, 31, 33, 352, 368, 380, 522). Ames: Carver 1892. Avoca: Bartholomew 1921 (Barth. N. Amer. Ured. 2531). Decorah: Holway 1884 (Arth. & Hol. Ured. Exsic. 39i), 1888**; 1888 (Sydow

Ured. 57), Ibid.**, 1903 (Vestgr. Mier. rar. sel.)*. Spirit Lake: Arthur 1898 (Arth. & Hol. Ured. Exsic. 39g), Ibid.*.

Winneshiek Co.: Goddard 1895.

On Andropogon scoparius Michx. (16, 25, 31, 53, 352, 368, 380).

Ames: Hume 1899; Pammel 1895. Boone: Pammel 1890.

Decorah: Holway——*. Spirit Lake: Arthur 1898 (Arth. & Holw. Ured. Exsic. 39d).

On Andropogon tennessensis Scribn. Ames: Hume 1899.

On Castilleja coccinea (L.) Spreng. (16, 31, 253)

On Castilleja sessiliflora Pursh. (16, 25, 31, 253). Ames: Warr 1884 ·

On Comandra pallida A.DC. (21, 25, 31, 522). Grundy Center:

Archer 1927 (Survey 792)

- On Comandra umbellata Nutt. (16, 31, 406, 522). Ames: Carver 1895; Hitchcock 1885-6; Thomas 1879. Decatur Co.: Anderson 1904. Decorah: Holway 1879; 1883 (Rabh. Wint. Fung. Eur. 3320)* **; 1885 (Barth. N. Amer. Ured. 964), Ibid.*; 1893 (Carleton Ured. Amer. 46), Ibid.* **. Lake Okoboji: Conard 1923**.
- On Penstemon gracilis Nutt. (25, 31)

On Penstemon grandiflorus Nutt. (25, 31)

556. Puccinia anemones-virginianae Schw. (25, p. 528)

Syn. Micropuccinia anemones-virginianae (Schw.) Arth. & Jackson. On Anemone canadensis L. Jefferson Co.: Smith 1927 (Survey 579b)

Exsic. eited: Ell. & Ev. Fung. Col. 1845; Arth. & Holw. Ured. 1c. Judging from the paucity of reports (N. Y. & Mich.) in the North American Flora, this species of Anemone would seem to be only rarely attacked. The one exsiccati (Fung. Col. 1845) was collected in New York. The Iowa collection corresponds with this specimen. The spores measure 37-54 x 10-13 μ and are the same as those in Holway (241, pl. 1, f. 10) and Arth. & Holw. Ured Exsic. & Icon. Fig. 12a & b.

On Anemone cylindrica Gray (16, 25, 31, 32, 53, 241). Ames:
 Bessey 1878, 1881; Blake 1899; Carver 1896**; Hitchcock 1885-6; Hodson 1900; Rolfs 1891. Ankeny: Pammel 1923.
 Decorah: Holway 1885 (Arth. & Holw. Ured. Exsic. 12a),

Ibid.*; 1887**; 1902*. Jewell Jct.: Carver 1895.

On Anemone quinquefolia L. Ames: Rolfs and Pammel 1891.

Winneshiek Co.: Goddard 1895.

On Anemone virginiana L. (16, 25, 31, 522). Ames: Carver 1892; Halsted 1886**; Rolfs and Pammel 1891. Decatur Co.: Anderson 1905. Decorah: Holway 1879*, 1885. Humboldt: Archer 1927 (Survey 1214). Winneshiek Co.: Goddard 1895

Puccinia anemones-virginianae on Anemone patens L. = Puccinia pulsatillae

557. Puccinia angustata Pk. (25, p. 343)

Syn. Dicaeoma angustatum (Pk.) Ktze.

On Cyperus strigosus L. — Puccinia canaliculata

On Eriophorum angustifolium Roth, = Puccinia eriophori

On Lycopus americanus Muhl. (Lycopus sinnatus Ell.). Lake Okoboji: Conard 1923**. On Scirpus sp. Ames: Ball 1896**.

On Scirpus atrovirens Muhl. (16, 25, 31, 522). Ames: Bessey 1878; Carver 1892; Crane 1896. Charles City: Arthur 1882**. Decorah: Holway 1885 (Barth N. Amer. Ured. 817) Ibid.*; 1893*. Des Moines: Carver 1895.

On Scirpus cyperinus (L.) Kunth. (25, 31)

On Scirpus fluviatilis (Torr.) Gray. North Liberty: Martin 1924**.

558. Puccinia antirrhini Diet. & Holw. (25, p. 594)

On Antirrhinum majus L. (cult. snapdragon) (15, 25, 31, 376). Des Moines: Wilson 1914. Maguoketa: D. R. Porter 1924.

559. Puccinia apocrypta Ell. & Tracy (25, p. 332)

Syn. Dicaeoma apocrypta (Ell. & Tracy) Arth.

On Agropyron tenerum Vasey. Rock Rapids: Pammel 1918.

On Ellisia nyctelea L. (Nemophila microcalyx) (31, 522). Decorah: Holway 1885**; 1888 (Barth. N. Amer. Ured. 705), Ibid.*. Iowa: Holway 1879, 1879*. Decatur Co.: Anderson 1904.

On Hydrophyllum virginianum L. (16, 25, 31, 253). Ames: Thomas 1879. Grinnell: Conard 1923**.

Puccinia argentata (Schultz) Wint. = Puccinia nolitangeris

Puccinia arundinariae Schw. (16, 53) cannot be definitely placed.

560. Puccinia asparagi DC. (25, p. 376)

Syn. Dicaeoma asparagi (DC.) Kuntze.

On Allium cepa L. (25). Decorah: Holway 1902 (Barth. N. Amer. Ured. 1526), Ibid.*

Holway (241) and Walker (506a) have described the infection of

onion by this fungus.

Puccinia asperfolii (Pers.) Wettst. — Puccinia dispersa

561. Puccinia asteris Duby (25, p. 575)

Syn. Micropuccinia asteris (Duby) Arth. & Jackson

On Aster sp. Winneshiek Co.: Goddard 1895.

On Aster azureus Lindl. (16, 25, 31). Ames: Bessey 1877; Obrecht 1899.

On Aster cordifolius L. (25, 31, 522)

On Aster laevis L. Vail: Archer 1927 (Survey 1245)

On Aster lateriflorus (L.) Britton (25, 31) On Aster novae-angliae L. (16, 25, 31, 53)

On Aster paniculatus Lam. (16, 25, 31, 53, 522) (not Aster simplex as reported by Thomas). Ames: Thomas 1878.

On Aster puniceus L. (25, 31). Decorah: Holway 1895 (Barth. N. Amer. Ured. 1332); Fbid.*

On Aster sagittifolius Willd. Mondamin: Archer 1927 (Survey 1288)

- On Aster salicifolius Ait. (cult.). Ames: Archer 1927 (Survey 1407)
- On Aster tradescanti L. Ames: Hill 1907
- 562. Puccinia asterum (Schw.) Kern. (25, p. 362) Syn. Dicaeoma asterum (Schw.) Arth. & Kern.
 - On Aster sp. Decorah: Holway 1878*, 1879*. Winneshiek Co.: Goddard 1895
 - On Aster cordifolius L. (16, 25, 31, 522). Ames: Bessey 1875-8.
 - On Aster drummondii Lindl. (25, 31). Decorah: Holway 1901 (Barth. Fung. Col. 4053); 1909; (Barth. N. Amer. Ured 534), Ibid.*. Floyd Co.: Smith & Gilman 1926.
 - On Aster laevis L. (31). Decatur Co.: Anderson 1901, 1904. Maynard: Archer 1927 (Survey 752)

On Aster paniculatus Lam. (25, 31)

On Aster sagittifolius Willd. (25, 31). Ames: Walker 1899; Archer 1927 (Survey 587)

On Aster undulatus L. Ames: Hitchcock 1885-6

On Boltonia asteroides (L.) L'Her. (25, 31, 253). Spirit Lake:
Arthur 1900*

On Carex sp. (8, 31)

On Carex adusta Boott. (16)

On Carex brevior (Dewey) MacKenzie (25, 31)

On Carex cephalophora Muhl. (25, 31, 522)

On Carex foenea Willd. (19, 25, 31). Decorah: Holway 1900*; 1901 (Barth. N. Amer. Ured. 535), Ibid.*

On Carex normalis MacKenzie (C. rosea) (25, 31)

- On Carex pennsylvanica Lam. (25, 31). Decorah: Holway 1887 (Barth, N. Amer. Ured. 1031), Ibid.*; 1886 (Barth. N. Amer. Ured. 1032), Ibid.*
- On Carex praegracilis W. Boott. (Carex marcida Boott.) (25, 31)
- On Carex sparganioides Muhl. (25, 31)
- On Carex stipata Muhl. (25, 31)
- On Carex straminea Schk. (16) On Carex stricta Lam. (16, 53)
- On Carex tribuloides Schk. Winneshiek Co.: Goddard 1895

On Carex vulpinoidea Michx. (25, 31) On Erigeron sp. Ames: Halsted 1885**

- On Erigeron annuus (L.) Pers. (25, 31, 522). Decatur Co.: Anderson 1901. Decorah: Holway 1885 (Barth. N. Amer. Ured. 828), Ibid.*
- On Erigeron canadensis L. (Leptilon canadense (L.) Britt.) (25, 31, 522). Decatur Co.: Anderson 1897-1909. Jewell Jct.: Hitchcock 1885-6. Rippey: Gilman and Archer 1927 (Survey 826)

On Erigeron philadelphicus L. (16, 25, 31, 199, 522). Ames: Hitchcock 1885-6; Thomas 1879. Decatur Co.: Anderson

1904

On Erigeron ramosus (Walt.) BSP. (Erigeron strigosus Muhl.) (16, 25, 31). Decorah: Holway 1879*, 1879. Muscatine Co.: Layton 1927 (Survey 1024)

On Polymnia canadensis L. (25, 31, 253, 522). Decorah: Holway 18—

On Solidago sp. Ames: Carver 1895; Hume 1899. Decorah: Holway —; (Ell. N. Amer. Fung. 1018c)

On Solidago altissima L. (25, 31)

On Solidago canadensis L. Decatur Co.: Anderson 1901

On Solidago glaberrima Martens (25, 31)

On Solidago latifolia L. (Solidago flexicaulis L.) (16, 25, 31, 522).

Ames: Hitchcock 1885-6. Ledges—Boone: Archer 1927 (Survey 645)

Ledges—Boone: Archer 1927 (Survey 645)

On Solidago rigida L. (16, 25, 31)

On Solidago serotina Ait. (16, 25, 31, 522). Decatur Co.: Anderson 1897

On Solidago ulmifolia Muhl. (25, 31, 522). Decatur Co.: Anderson 1901

563. Puccinia atropuncta Pk. & Clint. (25, p. 372)

Syn, Dicaeoma atropunctum (Pk. & Clint.) Kuntze

On Zygadenus chloranthus Richards (Anticlea chlorantha (Richards) Rydb.) (25, 31). Armstrong: Cratty, 1886*. Decorah: Holway 1884*, 1884 (Ell. N. Amer. Fung. 1447), Ibid.*. Emmet Co.: Cratty 1886*

564. Puccinia bardanae Cda. (25, p. 513)

Syn. Bullaria bardanae (Cda.) Arth.

On Arctium minus Bernh. (527). Boone: Archer 1927 (Survey 1187). New Hampton: Archer 1927 (Survey 746). Osage: Archer 1927 (Survey 1397)

Exsic. cited: Barth, N. Amer. Ured, 2539, 2540

Wilson (527) reported this rust in a paper read before the Iowa Academy of Science, but published only by title. In the Iowa material the teliospores measure $34\text{-}40 \times 20\text{-}27\mu$, which corresponds to the measurements of the spores in the Bartholomew specimen. In Arthur's description (25, p. 513) the measurements are given as $34\text{-}38 \times 23\text{-}26\mu$. The uredospores correspond to the measurements of the description.

565. Puccinia batesiana Arth. (25, p. 475)

Syn. Allodus batesiana Arth.

On Heliopsis scabra Dunal (25, 31, 336a). Ames: Hitchcock 1887*. Lake Okoboji: Conard 1923**

Puccinia bolleyana Kuntze — Puccinia sambuci

566. Puccinia calthae (Grev.) Lk. (25, p. 389) Syn. Dicaeoma calthae (Grev.) Kuntze

> On Caltha palustris L. (16, 25, 31, 362). Decorah: Holway 1879, 1879*; 1885 (Barth. N. Amer. Ured. 823), Ibid.*, 1888**

567. Puccinia calthaecola Schröt. (25, p. 390)

Syn. Dicaeoma calthaecola (Schröt.) Arthur

On Caltha palustris L. (25, 31, 362). Decorah: Holway 1893*, 1899*, 1902 (Barth. N. Amer. Ured. 1533), Ibid.*; Kovarik 1902*

568. Puccinia canaliculata (Schw.) Lagerh. (25, p. 344)

Syn. Dicaeoma canaliculatum (Schw.) Kuntze

On Cyperus erythrorhizos Muhl. Ames: Carver 1892; Warburton 1899

On Cyperus esculentus L. Ames: Pammel 1909. Indianola:

Archer 1927 (Survey 1086)

On Cyperus strigosus L. (16, 25, 31, 53, 283). Ames: Hitch-cock 1885-6. Decorah: Holway 1888**. Lake Okoboji: Conard 1923**

On Xanthium sp. (25, 31, 283). Ames: Gilman 1928

Puccinia caricis = Puccinia asterum

 $Puccinia\ caricis-asteris = Puccinia\ asterum$

Puccinia caricis-erigerontis = Puccinia asterum Puccinia caricis-solidaginis = Puccinia asterum

569. Puccinia caulicola Tracy & Galloway (25, p. 410)

Syn. Dicaeoma caulicola (Tr. & Gall.) Kuntze

On Salvia lanceaefolia Poir. (25, 31). Ames: Campbell 1908, 1908*; Pammel 1911. Indianola: Carver 1895. Mondamin:

· Archer 1927 (Survey 1273)

570. Puccinia cephalanthi (25, p. 318)

Syn. Dicaeoma cephalanthi (Seym.) Jackson. On Spartina michauxiana Hitche. (25, 31)

571. Puccinia chrysanthemi Roze.

On Chrysanthemum sp. (cult.) (406)

572. Puccinia circaeae Pers. (25, p. 548)

Syn. Micropuccinia circaeae (Pers.) Arth. & Jacks.

On Circaea lutetiana L. (8, 16, 25, 31, 53, 522). Ames: Bessey 1878; Blake 1899; Carver 1895; Hume 1899; Thomas 1878. Boone: Coe 1912. Decorah: Holway 1879*, 1885 (Arth. & Holw. Ured. Exsic. 2a), 1886*. Osage: Archer 1927 (Survey 1399)**. Winneshiek Co.: Goddard 1895

573. Puccinia cirsii Lasch. (25, p. 509)

Syn. Bullaria cirsii (Lasch.) Arth.

On Cirsium altissima (L.) Spreng. (Carduus altissimus L.) (16, 25, 31). Decorah: Holway 1885 (Barth. N. Amer. Ured. 935), Ibid.*

On Cirsium discolor (Muhl.) Spreng. (Carduus discolor (Muhl.) Nutt.) (25, 31). Ames: King 1911. Decorah: Holway 1878*, 1886 (Barth. N. Amer. Ured. 934), Ibid.*

On Cirsium iowense (Pammel) Fernald. Humboldt: Archer 1927 (Survey 1213)

574. Puccinia claytoniata (Schw.) Pk. (25, p. 457)

Syn. Allodus claytoniata (Schw.) Arth.

On Claytonia virginiana L. (25, 31, 241, 522). Ames: Berkhout 1924; Gilman 1924. Decorah: Holway 1885* ***, 1885 (Barth. N. Amer. Ured. 29), Ibid.*; 1889 (Barth. N. Amer. Ured. 538), Ibid.*; 1889*; 1889 (Syd. Ured. 323), Ibid.*

575. Puccinia clematidis (DC.) Lagerh. (25, p. 333)

Syn. Dicaeoma clematidis (DC.) Arth., Puccinia triticina Erikss.
On Actaea alba (L.) Mill. (25, 31) (See Aecidium cimicifugatum).

On Agropyron smithii Rydb. (25) On Agropyron tenerum Vasey (25, 31) On Anemone canadensis L. (16, 336)

- On Anemone cylindrica A. Gray. (25, 31). Ames: Walker 1899.

 Dubuque Co.: Pammel 1926. Winneshiek Co.: Goddard

 1895
- On Anemone quinquefolia L. (16, 25, 31). Decorah: Holway 1879. (Ell. N. Amer. Fung. 1003a), Ibid.*; Holway 1888 (Barth. N. Amer. Ured. 1003), Ibid.*

On Anemone virginiana L. (16, 25, 31)

- On Anemonella thalictroides (L.) Spach. (Syndesmon thalictroides (L.) Hoffung.). Decatur Co.: Anderson 1897. Eldora: Conard 1921**
- On *Bromus ciliatus* L. (23). *Decorah:* Holway 1903 (Barth. N. Amer. Ured. 870), Ibid.*; Holway 1903 (Barth. N. Amer. Ured. 871), Ibid.*; 1904**; Holway 1904**

On Bromus purgans L. (25, 31)

On Clematis sp. Winneshiek Co.: Goddard 1895

On Clematis viorna L. (25)

On Clematis virginiana L. (16, 25, 31). Ames: Halsted 1885**.
 Decorah: Holway 1879, 1879*, 1884**; Holway —— (Ell. N. Amer. Fung. 1005), Ibid.*. Ledges—Boone: Archer 1927 (Survey 637).

On Elymus canadensis L. (16, 25, 31, 352)

- On Elymus virginicus L. (25, 31). Decorah: Holway 1899 (Syd. Ured. 1380)*
- On Glyceria grandis S. Wats. (25, 31). Spirit Lake: Arthur 1894*, 1896*
- On Hordeum jubatum L. Ames: Carver 1892; Hume 1899. Iowa City: Hitchcock 1889**. Spirit Lake: Arthur 1898*
- On Isopyrum biternatum (Raf.) T. & G. (16, 25, 31, 253). Decorah: Holway 1883 (Barth, N. Amer. Ured. 707), Ibid.*, 1883*, 1886 (Rabenh. Wint. Pazsch. Fung. eur. 3836)*

On Phleum pratense L. Ames: King 1910 On Thalictrum sp. Decorah: Holway 1879*

On Thalictrum dasycarpum Fisch. & Lall. (T. purpurascens of Britt. and Br.) (16). Griswold: Dietz and Leach 1927 (Survey 595)¹

On Thalictrum dioicum L. Ames: Hitchcock 1885-1886

On Thalictrum polygamum Muhl. (T. purpurascens L., T. cornuti T. & G.) (16, 25, 31). Ames: Carver 1895; Hitchcock 1885-86; Smith 1924. Decorah: Holway 1882 (Ell. N. Amer. Fung. 1423), Ibid.*

On Thalictrum revolutum DC. Iowa City: Hitchcock 1889**

On Triticum vulgare Vill. (15, 16, 25, 31, 53, 191, 342, 352, 358, 360, 361, 367, 380, 383, 406). Ames: Bessey 1880; Campbell 1909; Hitchcock 1885-86; Pammel 1907; B. G. Porter 1907; Thuerlimann 1889 (Seym. & Earle Econ. Fung. 93); King 1912. Decorah: Holway 1879*. DeSoto: Minard 1907. Earlham: Phillips 1907. Marathon: Pammel 1908

¹Sowings of aecidiospores from *Thalictrum dasycarpum* (Survey 595) on wheat in the greenhouse at Ames in July 1927, by Dr. S. M. Dietz gave typical uredinia of *Puccinia elematidis*.

576. Puccinia cnici H. Mart. (25, p. 435)

Syn. Dicaeoma cnici (Mart.) Arth.

On Cirsium lanceolata (L.) Hill (Cnicus lanceolatus) (25, 31).

Ames: Carver 1896**; King 1911. Fraser: King 1911.

Stratford: Anderson 1913. Winneshiek Co.: Goddard 1895.

577. Puccinia convolvuli (Pers.) Cast. (25, p. 401)

Syn. Dicaeoma convolvuli (Pers.) Kuntze, Aecidium dubium Clint.,

Aecidium calystegiae Cast.

578. Puccinia coronata Cda. (25, p. 313)

Syn. Dicaeoma rhamni (Pers.) Kuntze

On Avena sp. Decorah: Holway 1884*

On Avena fatua L. (25). Decorah: Holway 1898 (Arth. & Holw.

Ured. Exsic. 31c). Jackson: Holway 1884*

On Avena sativa L. (cult. oats) (8, 15, 16, 25, 31, 191, 238, 352, 360, 367, 368, 376, 380, 383, 388, 389, 406, 522). Ames: Bessey 1882; Bettenga 1892; Hill 1907; King 1912; Paddock 1901; Pammel 1907. Armstrong: Cratty 1886. Decatur Co.: Anderson 1900. Decorah: Holway 1885 (Arth. & Holw. Ured. Exsic. 31a). DeSoto: Minard 1905. Lebanon: Sample 1898. Marathon: Pammel 1908. Mason City: Pammel 1908. Murray: Ashley 1908. Sac City: Pammel 1908. Waukon: Pammel 1908. Winneshiek Co.: Goddard 1895.

On Beckmannia erucaeformis (L.) Host. (25, 31)

On Calamagrostis canadensis (Michx.) Beauv. (25, 31). Ames: Carver 1892; Pammel 1891, 1897**, 1899. Greenfield: Archer 1927 (Survey 1114)

On Cinna arundinacea L. (16, 25, 31). Ames: Bessey 1878

On Dactylis glomerata L. (378, 406)

On Festuca elatior L. Ames: Bakke 1907

On Phleum pratense L. (10)

On Rhamnus sp. (406)

On Rhamnus alnifolia L'Her. (16, 25, 31). Decorah: Holway 1885 (Ell. & Ev. N. Amer. Fung. 2nd Ser. 1821)

On Rhamnus cathartica L. (10, 25, 31). Ames: Diehl 1916**.

Parkersburg: Stout 1894

On Rhamnus lanceolata Pursh. (8, 16, 360, 389). Boone Co.: Bessey 1874. Decatur Co.: Anderson 1904. Prescott: Morgan 1912

The specimen on *Phalaris arundinacea* L. reported by Arthur in his early list (16) is probably *Puccinia majanthae* (Schum.) Arth.

579. Puccinia cryptotaeniae Pk. (25, p. 551)

Syn. Micropuccinia cryptotaeniae (Pk.) Arthur & Jackson

On Cryptotaenia canadensis (L.) DC. (Deringa canadensis (L.) Kuntze) (16, 25, 31, 241). Decorah: Holway 1883*, 1885**,

1886*, 1888**, 1903 (Syd. Ured. 2020)*. *Eldora:* Conard 1920**. *Iowa City:* Hitchcock 1889**.

580. Puccinia cyperi Arth. (25, p. 345)

Syn. Dicaeoma cyperi (Arth.) Kuntze

On Cyperus filiculmis Vahl. Winneshiek Co.: Goddard 1895

On Cyperus schweinitzii Torr. (18, 25, 31). Ames: F. B. D. 1899. Conesville: Gilman 1927 (Survey 1313). Decorah: Holway 1886 (Barth. N. Amer. Ured. 837)*; 1886 (Barth. N. Amer. Ured. 838), Ibid.*. Winneshiek Co.: Goddard 1895

581. Puccinia cypripedii Arth. & Holw. (25, p. 381)

Syn. Dicaeoma (?) cypripedii (Arth. & Holw.) Arth.

On Cypripedium hirsutum Mill. (241). Decorah: Holway 1885

(Barth. N. Amer. Ured. 33), Ibid.*

On Cypripedium parviflorum var. pubescens (Willd.) Knight (16, 25, 31). Decorah: Holway 1884*, 1884 (Ell. N. Amer. Fung. 1473), Ibid.*, 1884 (Rabenh. Wint. Fung. eur. 3511)*, 1885*, 1886

582. Puccinia dayi Clint. (25, p. 553)

Syn. Micropuccinia dayi (Clint.) Arth. & Jackson

On Steironema ciliatum (L.) Raf. (Lysimachia ciliata L.) (16, 25, 31, 32, 241). Decorah: Holway 1884*, 1884 (Ell. N. Amer. Fung. 1453), Ibid.*; 1884 (Rabenh. Wint. Fung. eur. 3206)*; 1885 (Arth. & Holw. Ured. Exsic. 8)

583. Puccinia dispersa Erikss. (25, p. 331)

Syn. Dicaeoma asperifolii (Pers.) Kuntze.

On Secale cereale L. (cult. rye) (15, 25, 31, 191, 360, 376, 406).

Ames: Carver 1896**; King 1912.

584. Puccinia distichlidis Ell. & Ev. (25, p. 317)

Syn. Dicaeoma distichlidis (E. & E.) Kuntze.

On Spartina michauxiana Hitch. (25, 31). Ames: R. B. Howe —; Pammel 1909. Alton: Pammel 1923. Decorah: Holway 1882*.

585. Puccinia eatoniae Arth. (25, p. 324)

Syn. Dicaeoma eatoniae Arth.

On Ranunculus sp. Ames: Faurot 1900.

On Ranunculus abortivus L. (8, 16, 21, 522). Ames: Bessey 1875, 1878; Gilman 1924; Hitchcock 1885-6; Pammel 1891. Decatur Co.: Anderson 1903. Decorah: Holway 1879*, 1882 (Ell. N. Amer. Fung. 1003b), Ibid.*; 1885**.

On Sphenopholis sp. Ames: Bessey 1880.

On Sphenopholis obtusata (Michx.) Scribn. (Eatonia obtusata Michx.) Gray) (25, 31). Ames: Carver 1896**; Sirrine

1890 (Seym. & Earle Econ. Fung. 94)

On Sphenopholis pallens (Spreng.) Scribn. (Eatonia pennsylvanica Gray). Ames: Carver 1896**; Dietz 1927 (Survey 912); Pammel 1890 (Seym. & Earle Econ. Fung. 95). Decorah: Holway 1903*.

586. Puccinia eleocharidis Arth. (25, p. 347)

Syn, Dicaeoma eleocharidis (Arth.) Kuntze.

On Eleocharis intermedia (Muhl.) Schul. (16, 25, 31, 283). De-

corah: Holway 1886 (Barth. N. Amer. Ured. 938), Ibid.*. Spirit Lake: Arthur 1883*.

On Eleocharis palustris (L.) R. & S. (16, 25, 31, 53, 283).

Ames: Bessey 1878. Emmet Co.: Cratty 1886 (Barth, N. Amer. Ured. 985), Ibid.*.

On Eupatorium maculatum L. (25, 31, 283). Decorah: Holway 1885 (Barth, N. Amer. Ured 1043), Ibid.*.

On Eupatorium perfoliatum L. (16, 25, 31, 283). Lake Okoboji: Conard 1923**

On Eupatorium purpureum L. (16, 25, 31, 283, 522). Decorah: Holway 1901*. Spirit Lake: Arthur 1884*.

587. Puccinia ellisiana Thüm. (25, p. 280)

Syn, Dicaeoma mariae-wilsoni (Pk.) Arth. & Fromme.

On Andropogon furcatus Muhl. (25, 31). Ames: Pammel 1890.

On Andropogon scoparius Michx. (25, 31, 33). Ames: Carver 1892; Hume 1899. Decorah: Holway 1885 (Arth. & Holw. Ured. Exsic. 38b)

On Viola palmata L. (25, 31). Ames: Bessey 1873; Hitchcock 1885-6.

On Viola papilionacea Pursh. (25, 31)

On Viola pedata L. (16, 25, 31). Ames: Hitchcock 1885-86; Thomas 1879. Decorah: Holway 1883*.

On Viola pedatifida G. Don. (16, 25, 31). Ames: Bessey 1875; Hitchcock 1885-86. Decorah: Holway 1883*.

The specimens of aecidium on Viola pedata L. and V. pedatifida G. Don., which were earlier (16, 25) referred to Puccinia violae, have since (31) been shown to be P. ellisiana.

588. Puccinia emaculata Schw. (25, p. 290)

Syn. Dicaeoma emaculatum (Schw.) Kuntze.

On Panicum capillare L. (16, 25, 27, 31, 352, 380, 522). Ames: Bessey 1878; Blake 1899; Carver 1892; Hodson 1899; Hume 1899; Raymond 1891; Rolfs 1891. Decorah: Holway 1878; 1878*; 1885 (Arth. & Holw. Ured Exsic. 23a), 1886*; 1898 (Arth. & Holw. Ured. Exsic. 23d)

Puccinia epiphylla (L.) Wettst. = Puccinia poarum

589. Puccinia eriophori Thüm. (25, p. 344)

Syn. Dicaeoma eriophori (Thüm.) Kuntze.

On Eriophorum angustifolium Roth. (16, 25, 31). (Eriophorum viridicarinatum (Engelm.) Fernald). Decorah: Holway 1884*.

On Senecio aureus L. Decorah: Holway 1883*, 1883 (Ell. N. Amer. Fung. 1425), Ibid.*; 1886**.

Puccinia flosculosorum on Agoseris cuspidata (Pursh.) Steud. = Puccinia hieracii

Puccinia flosculosorum on Cirsium altissimum (L.) Spreng. = Puccinia cirsii

 $Puccinia\ flosculosorum\ on\ Taraxacum\ officinale\ Weber=Puccinia\ hieracii$ 590. Puccinia fraxinata (Lk.) Arth. (25, p. 316)

Syn. Dicaeoma fraxini (Schw.) Arth.

On Fraxinus sp. (342)

On Fraxinus americana L. (15, 25, 31, 406). Ames: Hume 1899. Decatur Co.: Anderson 1900.

On Fraxinus pennsylvanica Marsh. (16, 25, 31, 34, 197, 383)

- On Fraxinus pennsylvanica var. lanceolata (Borkh.) Sarg. (15, 16, 197, 383). Ames: Hitchcock 1885-86; Thomas 1879. Spirit Lake: Arthur 1899 (Arth. & Holw. Ured. Exsic. 54b); Halsted 1885*. Stanhope: Pammel 1927 (Survey 806). Storm Lake: Pammel 1923.
- On Spartina michauxiana Hitche. (Spartina cynosuroides Gray) (25, 31, 34, 522). Ames: Bessey 1877; Bettenga 1892; Carver 1892; Doty 1911; Halsted 1885**; Hodson 1899; Howe -; Hume 1899; Pammel 1897; Royse 1900; (Arth. & Holw, Ured, Exsic. 54g), (Ibid, 54k). Avoca: Bartholomew 1921 (Barth. N. Amer. Ured. 2755). Decorah: Holway 1884 (Syd. Ured. 262), Ibid.*; Holway 1885 (Arth. & Holw. Ured. Exsic. 54j); 1885**. Leon: Osborne 1925. Moore: Conard 1921**. Spirit Lake: Arthur 1904**.

The usage of Spartina michauxiana Hitche. varies with different workers. Wilson (522) uses Spartina cynosuroides (L.) Willd. Evidently he follows Coulter and Nelson's New Rocky Mountain Flora. These authorities presumably do not accept Spartina michauxiana Hitche. (S. cynosuroides Gray). See also Arthur (25, p. 317).

Puccinia fraxini = Puccinia fraxinata 591. **Puccinia fusca** Pers. (25, p. 152)

Syn. Polythelis fusca (Pers.) Arth.

On Anemone quinquefolia L. (16, 25, 31, 241, 522). Boone: Pammel 1913. Iowa: Holway 1879, 1879*. Decorah: Holway 1883 (Rabenh. Wint, Fung. eur. 3117)*; 1885 (Barth. Fung. Col. 3648); 1885 (Barth, N. Amer, Ured, 14), Ibid.*.

Puccinia fusca (Rhelh.) Wint, reported in Arthur's early list (16) on

Anemone patens var. nuttalliana Gr. is Puccinia suffusca Holw.

Puccinia galii = Puccinia punctata

Puccinia galiorum on Galium aparine L. = Puccinia ambigua Puccinia galiorum on Galium boreale L. = Puccinia rubefaciens

Puccinia galiorum on Galium concinnum T. & G. = Puccinia punctata

592. Puccinia gentianae (Stras.) Lk. (25, p. 400)

Syn. Dicaeoma gentianae (Stras.) Kuntze

On Gentiana puberula Michx. (Dasystephana puberula (Michx.) Small) (16, 25, 31, 490). Ames: Bessey 1876.

On Gentiana quinquefolia L. (16)

Puccinia gerardi Pk. = Puccinia asteris

Puccinia globosipes Pk. as reported from Iowa has since been shown to be Puccinia tumidipes.

593. Puccinia graminis Pers. (25, p. 295)

Syn. Dicaeoma poculiforme (Jacq.) Kuntze.

On Agropyron caninum (L.) Beauv. Northern Iowa: Webster 1910.

On Agropyron repens (L.) Beauv. (quack grass) (15, 25, 31, 352, 358, 378, 522). Jefferson: Carter 1912. Nora Springs: Yaggy 1924.

On Agropyron richardsonii Schrad, (378)

- On Agropuron smithii Rydb. (352, 358, 378). Ames: Pammel 1899
- On Agropuron tenerum Vasey (23, 25, 31, 378)

On Agrostis alba L. (406)

On Agrostis alba L. var. vulgaris Thurb. (8, 16, 25, 31, 352, 358, 378, 522). Ames: Bettenga 1892; Carver 1892; King 1910. 1911: Pammel 1911; Royse 1900. Decatur Co.: Anderson 1904. Decorah: Holway 1882 (Ell. & Ev. N. Amer. Fung. 1028); 1885 (Arth. & Holw. Ured. Exsic. 30h.) Indianola; Carver 1895. Martindale: Archer 1927 (Survey 1110)

On Agrostis huemalis (Walt.) BSP, (16, 25, 31)

On Alonecurus pratensis L. (378)

On Avena fatua L. (25, 31, 378). Ames: Carver 1896**. Decorah: Holway 1898 (Arth. & Holw, Ured. Exsic. 30g)

On Avena sativa L. (oats) (8, 15, 16, 25, 31, 53, 191, 358, 360. 367, 368, 376, 378, 380, 383, 406). Ames: Anderson 1913: Bessey 1880, 1882; Carver 1894; Combs 1894; Pammel 1889; Stewart 1893. Iowa City: Hitchcock 1889**. Marathon: Pammel 1908**. Mason City: Pammel 1908**. doah: Archer 1926**. Winneshiek Co.: Goddard 1895.

On Berberis canadensis L. (389)

On Berberis cerasina Schrad. (389) (not B. cerasiforme as re-

ported (389))

On Berberis vulgaris L. (8, 15, 16, 25, 31, 380, 383, 389). Ames: Ball 1894; Bessey 1876, 1881; Raymond 1891. Chickasaw Co.: Lonsdale 1876. Decorah: Holway 1881, 1892 (Arth. & Holw, Ured, Exsic. 30r), 1883*.

On Berberis vulgaris x Berberis thunbergii, Forest City: Smith

1926.

- On Bromus secalinus L. (10, 25, 31, 378). Decorah: Holway
- On Dactylis glomerata L. (25, 31, 378). Ames: Anderson 1913; King 1910: Pammel 1896, Decorah: Holway 1891 (Arth. & Holw. Ured. Exsic. 30j)

On Echinochloa crus-galli (L.) Beauv. (25, 31). Nordness: Ko-

varik 1898*.

On Elymus canadensis L. (16, 23, 25, 31, 378). Spirit Lake: Arthur 1904**.

On Elymus macounii Vasey (378)

On Elymus robustus Scribn. & Sm. (378). Story City: Archer 1927 (Survey 677)

On Elymus striatus Willd. Ames: King 1910.

On Festuca elatior L. (25, 31). Ames: Pammel 1910. Musca-

tine Co.: Layton (Survey 1499)

- On Hordeum jubatum L. (25, 31, 406). Ames: Anderson 1913; Carver 1892; Combs 1894; Pammel 1889; Raymond 1891. Decorah: Holway 1898 (Arth. & Holw. Ured. Exsic. 30m). Spirit Lake: Arthur 1896 (Arth. & Holw, Ured. Exsic. 30k)
- On Hordeum pammeli Scribn. & Ball. Sibley: Pammel 1918.

- On *Hordeum vulgare* L. (barley) (15, 25, 31, 191, 342, 406). *Ames:* King 1912; Lummis 1901; Raymond 1891; Stewart 1893.
- On Muhlenbergia cuspidata (Torr.) Rydb. (25, 31)
- On Muhlenbergia mexicana (L.) Trin. (16, 25, 31)
- On Notholcus lanatus (L.) Nash. (Holcus lanatus L.) (389)
- On Phleum pratense L. (timothy) (8, 15, 25, 31, 191, 374, 378, 385, 406). Ames: Anderson 1913; King 1910, 1911, 1912; Martin 1911**; Pammel 1910.
- On Poa pratensis L. (8)
- On Secale cereale L. (cult. rye) (15, 191, 342, 360, 378, 406)
- On Triticum polonicum L. (25, 31)
- On Triticum vulgare Vill. (cult. wheat) (Triticum aestivum L.) (8, 15, 16, 25, 31, 53, 191, 342, 352, 358, 360, 361, 376, 378, 380, 383, 388, 406). Ames: Anderson 1913; Atkinson 1898; King 1912; Pammel 1889. Boone: Coe 1912. Decorah: Holway 1886 (Arth. & Holw. Ured. Exsic. 30a). Hawkeye: Krueger 1912.
- 594. Puccinia grindeliae Pk. (25, p. 576)
 - Syn. Micropuccinia grindeliae (Pk.) Arth. & Jacks.
 - On Carex stipata Muhl, (20)
 - On Solidago sp. Decorah: Holway 1893*.
 - On Solidago nemoralis Ait. (25, 31). Decorah: Holway 1893 (Barth. N. Amer. Ured. 1077), Ibid.*.
- 595. Puccinia grossulariae (Schum.) Lagerh. (25, p. 355)
 - Syn, Dicaeoma grossulariae (Schum.) Kuntze.
 - On Carex spp. Ames: Bettenga 1892; Hume 1899. Ledges— Boone: Coe 1912. Winneshiek Co.: Goddard 1895.
 - On Carex crinita Lam. Ames: Bettenga 1892.
 - On Carex laxiflora Lam. var. blanda (Dewey) Boott (25, 31).

 Ames: Melhus 1924. Decorah: Holway 1892**.
 - On Carex pubescens Muhl. (25, 31). Decorah: Holway 1884 (Barth, N. Amer, Ured. 1079), Ibid.*; 1902**.
 - On Carex riparia W. Curtis (Carex lacustris Willd.) (20, 25, 31). Decorah: Holway 1886*, 1903*.
 - On Carex sparaganioides Muhl. (25, 31). Avoca: Bartholomew 1921 (Barth. N. Amer. Ured. 2659)
 - On Carex stipata Muhl. (25, 31). Decorah: Holway 1901*.
 - On Carex stricta Lam. Decorah: Holway 1886 (Barth, N. Amer. Ured. 1048), Ibid.*.
 - On Carex substricta (Kükenth.) MacKenzie (25, 31)
 - On Ribes sp. (Hort. var. Houghton gooseberry). Decatur Co.: Anderson 1901.
 - On Ribes alpinum L. (361)
 - On Ribes cynosbati L. (Grossularia cynosbati (L.) Mill.) (16, 25, 31, 522). Ames: Hitchcock 1885-86. Boone: Anderson 1913. Decorah: Holway 1899 (Barth. N. Amer. Ured. 1025), Ibid.*, 1903*. Manchester: Hoyt 1880. Waukon: Pammel 1913.
 - On Ribes floridum L'Her. (Ribes americanum Mill.) (16, 25, 31, 240, 522). Ames: Bessey 1881; Carver 1895; Pammel 1887.

Decorah: Holway 1883*, 1902*, 1903*, 1904 (Vestergr. Micr. rar. sel. 1038)*. Ellsworth: Leach 1927 (Survey 670). Iowa

City: Hitchcock 1889**. Springfield: Young 1905.

On Ribes gracile Michx. (R. missouriensis Nutt., Grossularia missouriensis (Nutt.) Cov. & Britton.) (16, 19, 25, 31, 368, 380, 522). Ames: Bessey 1880; Hitchcock 1885-86; Hume 1899; Thomas 1879. Decatur Co.: Anderson 1904. Decorah: Holway 1886 (Barth. N. Amer. Ured. 1047), Ibid.*, 1901 (Barth. N. Amer. Ured. 1152), Ibid.*. Grinnell: Conard 1923**. Ledges—Boone: Coe 1912. Winneshiek Co.: Goddard 1895. Winterset: Pammel 1925.

On Ribes grossularia L. (Grossularia reclinata Mill.) (cult. gooseberry) (25, 31, 368, 376, 380, 383, 406)

On Ribes rotundifolium Michx. (75, 368)

596. Puccinia helianthi-mollis (Schw.) Jackson (25, p. 427)

Syn. Dicaeoma helianthi-mollis (Schw.) Arth.

- On Helianthus annuus L. (8, 25, 31, 368, 380, 406, 522). Ames:
 Bettenga 1892; Carver 1892, 1893; Crane 1896; Combs 1894;
 Faurot 1900; Pammel 1892, 1895, 1902; Raymond 1891;
 Rolfs 1891; Stewart 1894. Decorah: Holway 1885*, 1887**.
 Marshalltown: Pammel 1902. Onawa: Pammel 1894. Winneshiek Co.: Goddard 1895.
- On Helianthus debilis Nutt. (cult.) (15). Ames: Archer 1927 (Survey 1566)
- On Helianthus decapetalus L. (25, 31, 522). Ames: Carver 1895.
- On Helianthus doronicoides Lam. (25, 31, 522). Ames: Bessey 1877. Decorah: Holway 1885*, 1885 (Barth. N. Amer. Ured. 947). Ibid.*

On Helianthus giganteus L. (cult. giant sunflower) (15). Mon-

damin: Archer 1927 (Survey 1261)

- On Helianthus grosse-serratus Martens (16, 25, 53, 368, 380, 522).

 Ames: Bessey 1876; Bettenga 1892; Carver 1895; Combs 1894; Hitchcock 1885-6; Howe ——; Hume 1899; King 1910; Pammel 1909; Raymond 1891; Stewart 1894; Wright 1892.

 Grinnell: Conard 1923**.
- On Helianthus laetiflorus Pers. (23, 25, 31). Decorah: Holway 1886**. Spirit Lake: Arthur 1904**.

On Helianthus maximiliani Schrad. (16, 25, 31)

On Helianthus mollis Lam. (25). Grinnell: Conard 1920**.

On Helianthus occidentalis Ridd. (16, 25, 31). Decorah: Holway 1885 (Barth, N. Amer. Ured. 1052), Ibid.*. Jordan: Dohrman 1899.

On Helianthus petiolaris Nutt. Ames: King 1910.

On Helianthus scaberrimus Ell. (16, 25, 31, 53). Ames: Bessey 1877. Decorah: Holway 1878*, 1885*; 1888 (Barth. N. Amer. Ured 1054), Ibid.*. Pocahontas: Archer 1927 (Survey 1351)

On Helianthus strumosus L. (16, 25, 31, 522). Ames: Bakke 1907; Buchanan 1901; Hitchcock 1885-86. Cushing: Pammel

1906. Decorah: Holway 1886 (Barth, N. Amer. Ured. 847), Ibid.*.

On Helianthus tracheliifolius Mill. (25, 31, 522)

On Helianthus tuberosus L. (8, 16, 25, 31, 53, 368, 380). Ames:
Bakke 1907; Bettenga 1892; Combs 1894; King 1910; Pammel 1911. Decatur Co.: Anderson 1904. Fairport:

1913**. Liscomb: Pammel 1913.

597. Puccinia heucherae Schw. (25, p. 535)

Syn. Micropuccinia heucherae (Schw.) Arth. & Jackson.

On Mitella diphylla L. (16, 25, 31, 32, 241). Decorah: Holway 1884 (Ell. N. Amer. Fung. 1464), Ibid.*; 1885 (Arth. & Holw. Ured. Exsic. 6a); 1886**, 1888**, 1891*. Winneshiek Co.: Goddard 1895.

598. Puccinia hibisciata (Schw.) Kellerm. (25, p. 308)

Syn. Dicaeoma hibisciata (Schw.) Arth.

On Muhlenbergia cuspidata (Torr.) Rydb. (25)

On Muhlenbergia mexicana (L.) Trin. (25, 31, 34). Conesville: Gilman and Layton 1927 (Survey 1500). Decorah: Holway (Ell. & Ev. N. Amer. Fung. 1854), Ibid.*; Holway 1884 (Arth. & Holw. Ured. Exsic. 50b)

On Muhlenbergia schreberi J. F. Gmelin (25, 31, 522). Ames:

Pammel 1910.

On Napaea dioica L. (16, 31). Decorah: Holway 1899.

599. Puccinia hieraciata (Schw.) Jackson (25, p. 366)

Syn, Dicaeoma hieraciatum (Schw.) Arth,

On Carex sp. Ames: Bessey 1878; Carver 1892.

On Carex grisea Wahl. (25, 31)

On Carex siccata Dewey (25, 31). Decorah: Holway 1887 (Barth. N. Amer. Ured. 1066), Ibid.*.

On Krigia amplexicaulis Nutt. (Adopogon virginicum (L.) Ktze.)

(31). Decorah: Holway 1885*.

On Lactuca canadensis L. (25, 31, 522). Ames: Hitchcock 1885-86¹; Hodson 1900¹; Hume 1899; Pammel 1908. Council Bluffs: Pammel 1908. McGregor: Pammel 1918.

On Lactuca ludoviciana (Nutt.) DC. (25, 31)

On Lactuca pulchella (Pursh) DC. (25, 31, 522)

600. Puccinia hieracii (Schum.) Mart. (25, p. 513)

Syn. Bullaria hieracii (Schum.) Arth.

On Hieracium canadense Michx. (25, 31). Decorah: Holway 1884*, 1888 (Barth, N. Amer, Ured, 850), Ibid.*

On Nothocalais cuspidata (Pursh) Greene (Agoseris cuspidata (Pursh.) Steud.) (16, 25, 31). Decorah: Holway 1881*, 1883*.

On Taraxacum erythrospermum Andrz. Grundy Center: Archer 1927 (Survey 532)**

On Taraxacum officinale Weber (Leontodon taraxacum L., Taraxacum dens-leonis Desf.) (8, 16, 25, 31, 53, 406, 522). Ames: Carver 1892; 1896**; Hitchcock 1885-86; Halsted 1885**;

Fide-Arthur.

King 1910; 1912; Rolfs 1891; Wright 1892. Decorah: Holway 1878; 1886**. Grinnell: Conard 1923**. Turin: Pammel 1894. Winneshiek Co.: Goddard 1895.

601. Puccinia hydrophylli Pk. & Clint. (25, p. 557)

Syn. Micropuccinia hydrophylli (P. & C.) Arth. & Jackson.

On Ellisia nyctelea L. (Nemophila microcalyx (Nutt.) F. & M.)

(8, 16, 253, 522)

On Hydrophyllum virginianum L. (16, 25, 31, 241, 522). Decorah: Holway 1880, 1880*; (Ell. N. Amer. Fung. 1043), Ibid.*; 1884**; 1888**; 1893**; 1886 (Barth. N. Amer. Ured. 346), Ibid.*; 1893 (Carlet. Ured. Amer. 16), Ibid.*; 1889 (Syd. Ured. 472)

602. Puccinia hyssopi Schw. (25, p. 561)

Syn. Micropuccinia hyssopi (Schw.) Arth. & Jackson.

On Agastache nepetoides (L.) Kuntze (16, 25, 31). Decorah: Holway 1884*, 1886**.

603. Puccinia impatientis (Schw.) Arth. (25, p. 337)

Syn. Dicaeoma impatientis (Schw.) Arth.

On Agrostis sp. Ames: Bettenga 1892.

On Elymus canadensis L. (25, 31, 522).

On Elymus robustus Scribn. & Smith (385). On Elymus striatus Willd. Ames: King 1910.

On Impatiens sp. Ames: Combs 1894; Hitchcock 1885-86,

On Impatiens biflora Walt. (I. fulva Nutt.), Lake Okoboji: Conard 1923**. Winneshiek Co.: Goddard 1895.

On Impatiens pallida Nutt. (I. aurea Muhl.) (25, 31, 522). Ames:
Bessey 1880. Decorah: Holway 1885**; 1886 (Barth. N.
Amer. Urcd. 852). Ibid.* Spirit Lake: Halsted 1885**.

On Phleum pratense L. (385).

604. Puccinia iridis (DC.) Rabenh. (25, p. 379)

Syn. Dicaeoma iridis (DC.) Kuntze.

On Iris versicolor L. (16, 25, 31, 241). Decorah: Holway 1879*; 1879 (Thüm. Myc. univ. 2042), Ibid.*, 1880; 1884 (Barth. N. Amer. Ured. 1160), Ibid.*

605. Puccinia jamesiana (Pk.) Arth. (25, p. 320) Syn. Dicaeoma jamesianum (Pk.) Arth.

On Asclepias syriaca L. (Asclepias cornuti Dene.) (8, 16, 25, 31).

Decatur Co.: Anderson 1897-1905. Decorah: Holway 1885**;
1886 (Barth. N. Amer. Ured. 928) Ibid.*

On Asclepias tuberosa L. (10, 16, 25, 31). Decorah: Holway

1881 (Ell. N. Amer. Fung. 1012) Ibid.*

On Boutelous curtipendula (Michx.) Torr. (16, 25, 31). Hamburg: Pammel 1918. Rock Rapids: Pammel 1918. Sioux City: Bartholomew 1921 (Barth. N. Amer. Ured. 2550).

606. Puccinia jussiaeae Speg. (25, p. 461)

Syn. Allodus jussiaeae (Speg.) Arth. & Ort.

On Ludvigia polycarpa Short and Peter (25, 31, 241, 336a).

Iowa City: Hitchcock 1889**, Kern 1906*.

Puccinia kelseyi Syd. on Spartina cynosuroides L. = Puccinia distichlidis

607. Puccinia kuhniae Schw. (25, p. 503)

Syn. Bullaria kuhniae (Schw.) Kern.

On Kuhnia eupatorioides L. (25, 31, 522). Carson: Archer 1927 (Survey 1588). Decorah: Holway 1888 (Syd. Ured. 69): 1888 (Barth, Fung. Col. 4268); 1898 (Barth, N. Amer. Ured. 644), Ibid.*. Winneshiek Co.: Goddard 1895.

608. Puccinia lobeliae W. Gerard (25, p. 571)

Svn. Micropuccinia lobeliae (Gerard) Arth. & Jackson.

On Lobelia spicata Lam. Grundy Center: Archer and Layton

1927 (Survey 789).

On Lobelia siphilitica L. (16, 25, 31, 32, 53). Ames: Bessey -(Ell. N. Amer. Fung. 253) Ibid.*; Hodson 1899; Bessey 1878; Thomas 1879. Decorah: Holway 1892 (Sydow Ured. 774), 1884*, 1885 (Arth. & Holw. Ured. Exsic. 3).

Puccinia lolii Niels. = Puccinia coronata.

609. Puccinia magnusiana Körn. (25, p. 323)

Syn. Dicaeoma magnusianum (Körn.) Kuntze.

On Anemone canadensis L. (A. pennsylvanica L.) (31) Ames:

Bessey 1878; Hume 1899.

On Phragmites communis Trin. (25, 31). Ames: Carver 1892; Halsted and Fairchild (Ell. & Ev. N. Amer. Fung. 2nd Ser. 2238), Ibid.*; Hodson 1899; Pammel — ... Colo: Hodson 1899. Decorah: Holway 1885 (Syd. Ured. 274). Mason City: Holway 1883*. Steamboat Rock: Hume, Pammel and Fitz. 1899.

610. Puccinia majanthae (Schum.) Arth. & Holw. (25, p. 298)

Syn Dicaeoma majanthae (Schum.) Arth.
On Iris versicolor L. (10, 16, 25, 31). Ames: Halsted 1885**. Decorah: Holway 1882; 1882 (Ell. N. Amer. Fung. 1014), Ibid*.

On Phalaris arundinacea L. (10, 16, 31). Decorah: Holway 1884

(Ell. N. Amer. Fung. 1475), Ibid.*

On Polygonatum biflorum (Walt.) Ell. (25, 31, 522). Decorah: Holway 1879 (Ell. N. Amer. Fung. 1421), Ibid.*; (Ell. N.

Amer. Fung. 229), Ibid.*

On Polygonatum commutatum (R. & S.) Dietr. (Polygonatum giganteum Dietr.) (16, 25, 31). Ames: Pammel and Hess 1901; Thomas 1879. Decatur Co.: Anderson 1904. Decorah: Holway 1878; 1885 (Arth. & Holw. Ured. Exsic. 44a). Spirit Lake Arthur 1901**.

On Smilacina racemosa (L.) Desf. (Vagnera racemosa (L.) Mor-

ong.) (25, 31), Decorah: Holway 1885*.

On Uvularia grandiflora Smith. Ames: Bessey 1878. Spirit Lake: Halsted 1885**.

611. Puccinia malvacearum Bertero (25, p. 542)

Syn, Micropuccina malvacearum (Bert.) Arth. & Jackson.

On Althaea rosea (L.) Cav. (cult. hollyhock) (15, 376). Iowa: City: Archer 1927 (Survey 1036)**. Sheldon: Smith 1926. Toledo: Conant 1918.

612. Puccinia marylandica Lindr. (25, p. 398)

Syn. Dicaeoma marylandica (Lindr.) Arthur.

On Sanicula marilandica L. (25, 31). Decorah: Holway 1893 (Barth, N. Amer. Ured, 765), Ibid.*

Puccinia maydis = Puccinia sorghi.

613. Puccinia menthae Pers. (25, p. 405)

Syn. Dicaeoma menthae Gray.

On Blephila hirsuta (Pursh.) Torr. (25, 31). Decorah: Holway 1885*, 1886 (Barth. N. Amer. Ured. 353), Ibid.*; 1886 (Syd. Ured. 275), Ibid.*. Winneshiek Co.: Goddard 1896.

On Mentha sp. (cult.). Grinnell: Conard 1923**.

- On Mentha arvensis var. canadensis (L.) Briquet (16, 25, 31, 53, 522). Ames: Bessey 1877; Carver 1894. Decorah: Holway 1882*. Hesper: Holway 1885 (Barth. N. Amer. Ured. 950), Ibid.*. Winneshiek Co.: Goddard 1895.
- On Monarda mollis L. (8, 16, 25, 31, 522). (not M. fistulosa as reported). Ames: Bessey 1877; Bettenga 1892; Blake 1899; Carver 1892; Combs 1894; Crane 1896; Hill 1907. Boone: Coe 1912. Cedar Rapids: Pammel 1901. Decatur Co.: Anderson 1904. Decorah: Holway 1878*, 1879***; 1887 (Barth. N. Amer. Ured. 853), Ibid.*. Jewell Jct.: Hitchcock 1885-86. Ledges-Boone: Archer 1927 (Survey 1193). Winneshiek Co.: Goddard 1895.

On Pycnanthemum pilosum Nutt. (Koellia pilosa (Nutt.) Brit-

ton) (25, 31, 522).

On Pycnanthemum virginianum (L.) Durand & Jackson (Koellia virginiana L. MacM.) (25, 31). Ames: Bessey 1877; Carver 1892. Charles City: Holway 1882 (Barth. N. Amer. Ured. 1062) (Reported on P. flexuosum). Decatur Co.: Anderson 1903. Winneshiek Co.: Goddard 1895.

614. Puccinia microica Ell. (25, p. 462)

Syn. Allodus microica (Ell.) Ort.

On Cryptotaenia canadensis DC. (Deringa canadensis (L.)

Kuntze) (25, 31).

Puccinia minuta Dietel is described from the southeastern United States and although reported for Iowa by Kern (282), Arthur does not accept this distribution (25, p. 354) and the specimens should be referred to Puccinia grossulariae.

615. Puccinia montanensis Ellis (25, p. 330)

Syn. Dicaeoma montanense (Ell.) Kuntze.

On Agropyron tenerum Vasey (25, 31). Ames: Carver 1896**.

On Elymus canadensis L. (25, 31).

On Elymus robustus Scribn. & Smith (25). Ames: Pammel 1902*.

On Elymus striatus Willd. (25, 31).

On Elymus virginicus L. Ames: Carver 1895.

On Hystrix patula Moench. (Hystrix hystrix (L.) Millsp.) (25, 31). Decorah: Holway 1899 (Barth. N. Amer. Ured. 328), Ibid.*; Holway 1899 (Barth. N. Amer. Ured. 327), Ibid.*

Puccinia muhlenbergiae = Puccinia hibisciata.

616. Puccinia nolitangeris Corda (25, p. 392)

Syn. Dicacoma noli-tangeris (Corda) Arth., Aecidium albescens Grev., Puccinia adoxae Hedw. f., Puccinia argentata (Schultz) Wint.

On Adoxa moschatellina L. (16, 25, 29, 31). Decorah: Holway 1879*, 1879; (Ell. N. Amer. Fung. 223), Ibid.*; 1885 (Barth. N. Amer. Ured. 17), Ibid.*

On Impatiens sp. Decorah: Holway 1878; (Ell. N. Amer. Fung. 251), Ibid.*

On Impatiens biflora Walt. (16, 25, 31, 241).

On Impatiens pallida Nutt. (16, 25, 31). Decorah: Holway 1883*, 1885*, 1892 (Syd. Ured. 760), Ibid.*

Sydow (484) names this species *Puccinia adoxae* Hedw. f., separating it from *Puccinia argentata* (Schultz) Wint. citing E. & E. 223 for the first and E. & E. 251 for the second. The aecidia on Krieger Fung. Sax. 1955 are scattered and larger than those on E. & E. 223. The American form is distinct from that of Europe.

617. Puccinia obscura Schröt. (25, p. 370)

Syn. Dicaeoma obscurum (Schröt.) Kuntze.

On Luzula intermedia (Thuill.) A. Nels. (Juncoides intermedium (Thuill.) Rydb.) (16, 25, 31). Estherville: Cratty 1882*.

618. Puccinia obtecta Pk. (25, p. 341)

Syn, Dicaeoma obtectum (Pk.) Kuntze.

On Scirpus validus Vahl. (Scirpus lacustris) (16, 25, 31, 53, 199).

Ames: Bessey 1878; Carver 1892, 1896**; Dillon 1898; Sample 1898. Decorah: Holway 1883*; Kovarik 1898*. Iowa: Halsted 1887 (Ell. & Ev. N. Amer. Fung. 2nd Ser. 2235).

Spirit Lake: Arthur 1898**. Winneshiek Co.: Goddard 1895.

Puccinia opizii Bubak — Puccinia hieraciata.

619. Puccinia, pammelii (Trel.) Arth. (25, p. 291)

Syn. Dicaeoma pammelii (Trel.) Arth.

On Euphorbia corollata L. (Tithymalopsis corollata (L.) Kl. Garcke) (25, 31). Decorah: Holway 1899*. West Union: Dunn 1926.

On Panicum virgatum L. (25, 31). Avoca: Bartholomew 1921 (Barth, N. Amer. Ured. 2556). Decorah: Holway 1887 (Arth. & Holw. Ured. Exsic. 20b); 1888**; 1898 (Arth. & Holw. Ured Exsic. 20c).

Puccinia panici Diet. — Puccinia pammelii.

Puccinia patruelis Arth. = Puccinia hieraciata.

620. Puccinia peckii (DeT.) Kellerm. (25, p. 365)

Syn. Dicaeoma peckii (DeT.) Arth.

On Carex sprengelii Dewey (Carex longirostris Torr.) (522).

On Carex trichocarpa Muhl. (20, 25, 31).

On Oenothera biennis L. (16, 25, 31, 522). Ames: Hitchcock 1885-86; Hume 1899; Smith 1924. Boone: Pammel 1927. Decorah: Holway 1879 (Ell. N. Amer. Fung. 1016), Ibid.*; 1885 (Barth. N. Amer. Ured. 53), Ibid.*; 1885**; 1888**. Ontario: Faurot and Paddock 1901.

On Oenothera lamarkiana Ser. Grinnell: Conard 1921**.

On Oenothera serrulata Nutt. (Merolix serrulata (Nutt.) Walp.) (16, 25, 31).

621. Puccinia periclymeni (Schum.) Barth. (25, p. 315)

Syn. Dicaeoma periclymeni (Schum.) Arthur and Fromme.

On Lonicera flava Sims (10, 25, 31). Decorah: Holway 1879;—(Ell, N. Amer, Fung. 1020).

On Lonicera sullivantii Gray (16)

Puccinia peridermiospora (E. & T.) Arth. = Puccinia fraxinata.

Puccinia phlei-pratense Erikss, = Puccinia graminis.

Puccinia phragmites (Schum.) Wint. (16) = Puccinia rubella.

622. Puccinia phrymae Halst. (25, p. 361)

Syn. Dicaeoma phrymae (Halst.) Arth. & Kern.

On Carex sprengelii Dewey (25, 31).

On Phryma leptostachya L. (25, 26, 31, 198, 282, 522). Decorah: Holway 1889*. Spirit Lake: Halsted 1885* **: 1886.

623. Puccinia physalidis Pk. (25, p. 562)

Syn. Micropuccinia physalidis (Pk.) Arth. & Jackson.

On Physalis lanceolata Michx. (25, 31).

624. Puccinia pimpinellae (Strauss.) Lk. (25, p. 396)

Syn. Dicaeoma pimpinellae (Strauss) Kuntze.

On Osmorhiza claytoni (Michx.) Clarke (16, 25, 31, 53, 522)

Ames: Carver 1895. Decorah: Holway 1884*, 1886 (Barth.
N. Amer. Ured. 650) Ibid.*. Spirit Lake: Halsted 1885**.

Winneshiek Co: Goddard 1895. Winterset: Carver 1895.

On Osmorhiza longistyles (Torr.) DC. (16, 25, 31, 522). Decorah: Holway 1882, 1883*; 1885 (Barth. N. Amer. Ured. 756), Ibid.*: 1886**.

625. Puccinia plumbaria Pk. (25, p. 468)

Syn. Allodus giliae (Pk.) Orton.

On Phlox spp. (10).

On Phlox divaricata L. var. laphamii (31, 74, 241). Decorah: Holway 1882, 1882*; 1883 (Ell. N. Amer. Fung. 1432), Ibid.*; 1885*; 1886 (Barth. N. Amer. Ured. 162), Ibid.*

On Phlox paniculata L. (522). On Phlox pilosa L. (25, 31).

The specimens reported by Arthur (16) on *Phlox divaricata* L. collected by Thomas 1879 and on *Phlox pilosa* L. collected by Bessey 1881 were *Uromyces polemonii* (Pk.) Barth, in the packets in our herbarium.

626. Puccinia poarum Niels. (25, p. 327)

Syn. Dicaeoma epiphyllum (L.) Kuntze.

On Poa pratensis L. (15, 25, 31, 53). Ames: Arthur 1882; Hitchcock 1885-86; King 1910. Boone: Archer 1927 (Survey 630). Rockwell City: Archer 1927 (Survey 688).

Puccinia poculiformis — Puccinia graminis. 627. Puccinia podophyllii Schw. (25, p. 458)

Syn. Allodus podophyllii (Schw.) Arth.

On Podophyllum peltatum L. (16, 25, 31, 53, 522). Ames: Bessey 1875, 1876, 1878; Carver 1892; Hume 1899. Boone: Perrin 1899; Underwood 1924. Decatur Co.: Anderson 1897, 1904,

1885 (Barth. N. Amer. Ured. 959), Ibid.*. *Decorah:* Holway 1879, 1879*, 1881, 1881*, 1883**, 1885*, 1885 (Barth. N. Amer. Ured. 256), Ibid.*, 1886**, 1888 (Syd. Ured. 76), Ibid.* *Iowa City:* Hitchcock 1889**. *McGregor:* Gilman 1926. *Winneshiek Co.:* Goddard 1895.

628. Puccinia polygoni-amphibii Pers. (25, p. 381)

Syn. Dicaeoma polygoni-amphibii Arth.

On Geranium sp. Winneshiek Co.: Goddard 1895.

On Geranium maculatum L. (16, 25, 31, 53). Ames: Ball 1894; Bessey 1878, 1881; Hitchcock 1885-86; Hume 1899; Pammel 1894. Boone: Pammel 1913; Perrin 1899. Decatur Co.: Anderson 1904. Decorah: Holway 1879*. Eldora: Pammel 1927 (Survey 618). McGregor: Smith 1926.

On Polygonum amphibium L. (522).

On Polygonum amphibium var. hartwrightii (Gray) Bissell (Persicaria hartwrightii) (16, 25, 31, 53). Ames: Thomas 1878. Winneshiek Co.: Goddard 1895.

On Polygonum amphibium var. terrestre Leers. Decorah: Holway 1884 (Ell. & Ev. N. Amer. Fung. 1859), Ibid.*

- On Polygonum convolvulus L. (Bilderdykia convolvulus (L.) Dumort) (25, 31, 241). Ames: Clark 1910; Hume and Walker 1899; Welch 1900. Muscatine Co.: Layton 1927 (Survey 1510).
- On Polygonum muhlenbergii (Meisn.) Wats. (Persicaria muhlenbergii Small) (16, 25, 31). Ames: Bessey 1878; Carver 1892; Howe ——; King 1911; Pammel 1895. Avoca: Bartholomew 1921 (Barth. N. Amer. Ured. 3160). Bedford: Bartholomew 1919 (Barth. N. Amer. Ured. 2260). Decorah: Holway 1885 (Barth. N. Amer. Ured. 1070), Ibid.* Delmar: Allison 1911. Hazleton: Pammel 1925. Spirit Lake: Arthur 1904**.

On Polygonum scandens L. Decatur Co.: Anderson 1904.

629. Puccinia polysora Underw. (25, p. 279)

Syn. Dicaeoma polysorum (Underw.) Arth.

On Tripsacum dactyloides L. (8).

Puccinia pringsheimiana Kleb. = Puccinia grossulariae.

630. Puccinia proserpinacae (Berk. & Curt.) Farl. (25, p. 396)

Syn. Dicaeoma proserpinacae (B. & C.) Kuntze.

On Proserpinaca palustris L. (16, 53). Boone: Arthur 1871.

631. Puccinia pruni-spinosae Pers. (25, p. 151)

Syn. Tranzschelia punctata (Pers.) Arth.
On Anemone quinquefolia L. (25, 31, 522). Decorah: Holway
1883 (Rabenh. Wint. Fung. eur. 3023a),* 1885 (Barth. N.
Amer. Ured. 878), Ibid.* Iowa: Holway 1879. Winneshiek
Co.: Goddard 1896.

On Hepatica acutiloba DC. (Anemone acutiloba Laws.) (16, 25, 31, 522). Boone: Underwood 1924. Decorah: Holway 1882*, 1885 (Barth. N. Amer. Ured. 1088), Ibid.*; 1885**; 1889 (Syd. Ured. 300), Ibid.*

On Prunus sp. (cult. peach) (15, 342).

¹This specimen was labeled P. epilobi DC. var. proserpinacae Farl.

On Prunus sp. (cult. plum) (15). .Osage: Archer 1927 (Survey 1393). Winneshiek Co.: Goddard 1895.

On Prunus americana Marsh. (31, 522). Decorah: Holway 1879*,

1885, 1886**.

On Prunus americana var. chippewa Hort. (355, 383). Ames: Pammel 1889 (Seym. and Earle Ec. Fung. 17), Ibid.*

On Prunus americana var. lanata Sudw. (25, 31).

On Prunus domestica L. (cult. plum) (406).

On Prunus hortulana Bailey. Decatur Co.: Anderson 1902.

On Prunus pennsylvanica L. Ledges-Boone: Archer 1927 (Survey 1576).

On Prunus persica (L.) Stokes (cult. peach) (341, 383, 406).

- On Prunus serotina Ehrh. (Padus serotina (Ehrh.) Ag.) (10, 16, 25, 31, 53). Ames: Bessey 1878, 1878*, 1887. Decorah: Holway 1895 (Syd. Ured. 1026), Ibid.* Winneshiek Co.: Goddard 1895.
- On Thalictrum dasycarpum Fisch. & Lall. Ames: Bessey 1876. Decorah: Holway 1882 (Ell. & Ev. N. Amer. Fung. 1004), Ibid.*; 1886 (Barth. N. Amer. Ured. 379), Ibid.*

On Thalictrum dioicum L. (25, 31).

On Thalictrum polygamum Muhl. (Thalictrum purpurascens L.) (25, 31).

Puccinia prunorum Link — Puccinia pruni-spinosae.

632. Puccinia pulsatillae Kalchbr. (25, p. 527)

Syn. Micropuccinia pulsatillae (Kalchbr.) Arth. & Jackson.

On Anemone patens L. var. nuttalliana Gray (Pulsatilla hirsutissima (Pursh.) Britton¹) (25, 31, 241). Decorah: Holway 1880*, 1883*, 1884 (Ell. N. Amer. Fung. 1456); 1886 (Arth. & Holw, Ured. Exsic. 12b), Ibid.*; 1899 (Syd. Ured. 1370)*.

633. Puccinia punctata Link. (25, p. 417)

Syn. Dicaeoma punctatum (Link) Arth.

On Galium asprellum Michx. (13, 25). Hesper: Holway 1885

(Barth. N. Amer. Ured. 962), Ibid.*

On Galium concinnum T. & G. (16, 25, 31, 53). Ames: Bessey 1877; Carver 1892; Pammel 1899; Thomas 1878. Decatur Co.: Anderson 1904. Decorah: Holway 1878*, 1883*, 1891 (Barth. N. Amer. Ured. 862), Ibid.* Winneshiek Co.: Goddard 1895.

On Galium tinctorium L. (522). On Galium trifidum L. (8).

Puccinia punctata Link on Galium aparine = Puccinia ambigua.

Puccinia pustulata (Curt.) Arth. —Puccinia andropogi.

Puccinia riparia Holw. = Puccinia grossulariae, 634. Puccinia rubefaciens Johans. (25, p. 568)

Syn, Micropuccinia rubefaciens (Johans.) Arth. & Jacks.

^{&#}x27;Not Pulsatilla ludoviciana (Nutt.) A. Heller as reported (25).

635. Puccinia rubella (Pers.) Arth. (25, p. 732)

Svn. Dicaeoma rubellum (Pers.) Arth. & Fromme.

On Phragmites communis (L.) Trin. (16, 31). Ames: Carver

Puccinia rubigo-vera (DC.) Wint, on Agropyron tenerum Vasey = Puccinia montanensis.

On Elymus spp. = Puccinia clematidis.

On Hordeum jubatum L. - Puccinia clematidis

On Secale cereale L. - Puccinia dispersa.

On Sphenopholis (Eatonia) spp. = Puccinia eatoniae.

On Triticum vulgare Vill. — Puccinia clematidis.

636. Puccinia ruelliae (Berk. & Br.) Lagerh. (25, p. 415) Syn. Dicaeoma ruelliae (Berk. & Br.) Kuntze. On Ruellia ciliosa Pursh. Madison Co.: Pammel 1919.

637. Puccinia sambuci (Schw.) Arth. (25, p. 368)

Syn. Dicaeoma sambuci (Schw.) Arth.

On Sambucus canadensis (16, 31). Iowa City: Hitchcock 1889**.

638. Puccinia seymouriana Arth. (25, p. 318) Syn. Dicaeoma cephalanthi (Seym.) Jacks.

> On Spartina michauxiana Hitche. Ames: Hume 1899; Reynolds 1883.

639. Puccinia silphii Schw. (25, p. 581)

Syn. Micropuccinia silphii (Schw.) Arth. & Jackson.

On Silphium integrifolium Michx. Decatur Co.: Anderson 1904. Dubuque Co.: Pammel & Kelley 1924. Jefferson Co.: Smith 1927 (Survey 580). Randolph: Archer 1927 (Survey 879). Shenandoah: Gilman and Archer 1927 (Survey 846).

On Silphium laciniatum L. Decorah: Holway 1884*, 1885**; 1890 (Arth. & Holw. Ured. Exsic. 4a); 1890 (Syd. Ured.

482), Ibid.* Spirit Lake: Arthur 1898**.

On Silphium perfoliatum L. (16, 25, 31, 32, 53, 522). Ames: Carver 1896**; Hitchcock 1885-6. Decorah: Holway 1882*, 1882 (Ell. & Ev. N. Amer. Fung. 1033), Ibid.*; 1884 (Arth. & Holw, Ured. Exsic. 4b), 1886 (Ibid. 4c). Spirit Lake: Halsted 1896**. Winneshiek Co.: Goddard 1895.

640. Puccinia simplex (Koern.) Eriks. & Henn. (25, p. 339)

Syn. Dicaeoma anomalum (Rostr.) Arth. & Fro.

On Hordeum vulgare L. (cult. barley) (15, 25, 31, 191, 406). Cedar Falls: Carver 1896**.

Puccinia solidaginis Pk. — Puccinia grindeliae.

641. Puccinia sorghi Schw. (25, p. 277)

Syn. Dicaeoma sorghi (Schw.) Kuntze.

On Holcus sorghum L. (Andropogon sorghum Brot.). Ledges-Boone: Coe 1912.

On Oxalis sp. Grundy Center: Archer 1927 (Survey 539).

On Oxalis corniculata L. (462). Indianola: Smith 1925.

On Oxalis europa (191). Lamoni: Leach and Dietz 1927.

On Oxalis stricta L. (Xanthoxalis stricta (L.) Small) (25, 31) Ames: Halsted 1885**. Decatur Co.: Anderson 1904. On Oxalis violacea L. (16, 22). Decorah: Holway 1907*.

On Zea mays L. (16, 25, 31, 53, 191, 342, 352, 368, 376, 380, 381, 383, 389, 522). Ames: Bettenga 1892; Bessey 1877; 1880; Blake 1899; Carver 1892; 1898**; Hodson 1899; King 1910, 1911; Pammel 1889, 1894, 1908**; Taylor 1894. Avoca: Bartholomew 1921 (Barth. N. Amer. Ured. 2680). Decatur Co.: Anderson 1904. Decorah: Holway 1884*, 1884 (Arth. & Holw. Ured. Exsic. 32a), 1885**, (Ibid. 32b), 1898*. Turin: Pammel 1894. Winneshiek Co.: Goddard 1895.

On Zea mays var. everta Bailey (pop corn) (15). On Zea mays var. indentata Bailey (dent corn) (15)

On Zea mays var, rugosa Bonaf, (sweet corn) (15, 191).

642. Puccinia sporoboli Arth. (25, p. 303)

Syn. Dicaeoma sporoboli (Arth.) Kuntze.
On Sporobolus asper (Michx.) Kunth.

Pammel (378) reported this species on Sporobolus asper but Arthur (31) found that the species on S. asper was Puccinia verbenicola.

On Sporobolus brevifolius (Nutt.) Scribn. (16, 378).

On Sporobolus cryptandrus (Torr.) Gray (378).

On Sporobolus heterolepsis Gray (16, 25, 31, 53). Decorah: Holway 1884*, 1885, 1884 (Arth. & Holw. Ured. Exsic. 25a), 1901*. 1902 (Vestergren micro. rar. sel. 566)**.

On Sporobolus neglectus Nash.

Arthur (31) reported only *Uromyces sporoboli* on this host. The specimen collected by Pammel labelled *Puccinia sporoboli* in the Iowa State College herbarium proved to be the *Uromyces sporoboli*.

On Sporobolus vaginiflorus (Torr.) Wood. (378).

Puccinia spreta — Puccinia heucherae. 643. Puccinia stipae Arth. (25, p. 300)

Svn. Dicaeoma stipae (Arth.) Kuntze.

On Aster multiflorus Ait. (23, 25, 31).

On Stipa spartea Trin. (16, 23, 25, 29, 31, 53, 199). Ames: Halsted 1887 (Ell. & Ev. N. Amer. Fung. 2245), Ibid.*; Hume 1899; Pammel 1896; (Ell. & Ev. Fung. Col. 1663); Pammel 1896. Decorah: Holway 1882*, 1890 (Arth. & Holw. Ured. Exsic. 27a). Spirit Lake: Arthur 1894,** 1896 (Arth. & Holw. Ured. Exsic. 27b); 1898 (Arth. & Holw. Ured. Exsic. 27c); 1897 (Barth N. Amer. Ured. 61), Ibid.*; 1897 (Barth. Fung. Col. 3466), 1904**.

Puccinia striatula Pk. - Puccinia majanthae.

644. Puccinia suffusca Holw. (25, p. 153)

Syn, Polythelis pulsatillae (Rostr.) Arth.

On Anemone patens L. var. nuttalliana Gray (16) (Pulsatilla hirsutissima (Pursh) Britton, Pulsatilla suffusca) (25, 31, 239, 241).

Holway (241 p. 12) considers this fungus as synonymous with $Puccinia\ thalictri.$

Puccinia tanaceti

On Artemisia dracunculoides Pursh = Puccinia absinthii.

On Artemisia ludoviciana Nutt. = Puccinia absinthii.

On Helianthus annuus L. — Puccinia helianthi-mollis.

On Helianthus grosse-serratus Martens — Puccinia helianthimollis.

On Helianthus maximiliani Schrad. = Puccinia helianthi-mollis.

On Helianthus occidentalis Riddell = Puccinia helianthi-mollis.

On Helianthus scaberrimus Ell. — Puccinia helianthi-mollis. On Helianthus strumosus L. — Puccinia helianthi-mollis.

On Helianthus tuberosus L. = Puccinia helianthi-mollis.

On Vernonia fasiculata Michx. = Puccinia vernoniae.

On Veronia noveboracensis Willd. = Puccinia vernoniae.

Puccinia taraxaci Plowr. = Puccinia hieracii.

645. Puccinia tenuis (Schw.) Burr. (25, p. 474)

Syn. Allodus tenuis (Schw.) Arth.

On Eupatorium urticaefolium Reichard. (25, 31). Decorah: Holway 1895 (Barth. N. Amer. Ured. 65), Ibid.*

646. Puccinia thalictri Chev. (25, p. 153)

Syn. Polythelis thalictri (Chev.) Arth.

On Thalictrum dioicum L. (16, 25, 31, 53). Ames: Bessey 1875; Hitchcock 1885-6; 1885-6*. Boone: Archer 1927 (Survey 633); Carver 1896**.

On Thalictrum polygamum Muhl. (T. purpurascens L., T. cornuti T. & G.) (25, 31). Ames: Pammel 1899.

Puccinia tompari Trel. — Puccinia clematidis. Puccinia triticina Eriks. — Puccinia clematidis.

647. Puccinia troglodytes Lindr. (25, p. 418) Syn. Dicaeoma troglodytes (Lindr.) Jacks.

On Galium triflorum Michx. (25, 31). Decorah: Holway 1884*, 1886 (Barth. N. Amer. Ured. 1376), Ibid.*

648. Puccinia tumidipes Pk. (25, p. 495) Syn. Bullaria tumidipes (Pk.) Arth.

On Lycium halimifolium Mill. (25, 31). Ames: Archer 1927 (Survey 1564). Council Bluffs: Bartholomew 1921 (Barth. N. Amer. Ured. 2566) Redding: Muncie 1923.

649. Puccinia universalis Arth. (25, p. 360 and p. 786) Syn. Dicaeoma martianoffianum (Thüm.) Arth.

On Artemisia camporum (Rydb. (25, 26).

650. Puccinia urticae (Schum.) Lagerh. (25, p. 358) Syn. Dicaeoma urticae (Schum.) Kuntze,

On Carex sp. Ames: Anderson 1913; Hitchcock 1885-86; Hume 1899; Pammel & Ball 1898. Decorah: Holway 1878 (Ell. N. Amer. Fung. 267), Ibid.*; 1879*. Greenfield: Stewart 1893. Moore: Conard 1917**. Mount Pleasant: 1903.

On Carex aquatilis Wahl. (25). Avoca: Bartholomew 1921 (Barth. N. Amer. Ured. 2683).

On Carex atheoides Spreng. (25, 31)

On Carex emoryi Dewey (C. stricta Lam.?) (25, 31). Decorah: Holway 1886 (Barth. N. Amer. Ured. 1081), Ibid.*; 1890 (Syd. Ured. 464).

On Carex riparia W. Curt. (C. lacustris Willd.) (25, 31). Decorah: Holway 1886 (Barth. N. Amer. Ured. 1082).

On Carex stricta Lam. (25, 31), Avoca: Bartholomew 1921 (Barth, N. Amer, Ured 2777).

On Urtica sp. Decorah: Holway—(Ell. N. Amer. Fung. 267).

Winneshiek Co.: Goddard 1895.

On Urtica gracilis Ait. (16, 25, 31, 522). Decorah: Holway 1879: 1883**. Estherville: Pammel 1907.

651. Puccinia verbenicola (Ell. & Kellerm.) Arth. (25, p. 303)

Svn. Dicaeoma verbenicola (E. & K.) Arth.

- On Sporobolus asper (Michx.) Kunth. (25, 31, 378). Ames: Hume 1899: Pammel 1898. Cedar Cliffs: Pammel 1887.
- On Sporobolus neglectus Nash, Ledward: Pammel & Cratty 1897. On Verbena stricta Vent. (8). Conesville: Archer 1927 (Survey

946). Fremont Co.: Hitchcock 1888. Webster City: Pammel

On Verbena urticaefolia L. Conesville: Archer 1927 (Survey 939) 652. Puccinia vernoniae Schw. (25, p. 497)

Syn. Bullaria vernoniae (Schw.) Arth.

On Vernonia baldwinii Torr. (V. interior Small) (25, 31). Avoca: Bartholomew 1921 (Barth, N. Amer, Ured, 2571). Indianola: Archer 1927 (Survey 1092).

On Vernonia fasciculata Michx. (8, 16, 25, 31, 53). Ames: Bessey 1877, 1878. Avoca: Bartholomew 1921 (Barth. N. Amer. Ured. 2780). Decatur Co.: Anderson 1904. Decorah: Holway 1878, 1878*; 1887 (Barth, N. Amer, Ured, 973), Ibid.*; 1884 (Barth. N. Amer. Ured. 874), Ibid.* Des Moines: Carver 1895. Indianola: Archer 1927 (Survey 1075).

On Vernonia noveboracensis Willd. (8, 16). Decatur Co.: An-

derson 1902, 1903. Des Moines: Pammel 1897.

 $Puccinia\ veronicae = Puccinia\ veronicarum.$ 653. Puccinia veronicarum DC. (25, p. 566)

Syn. Micropuccinia veronicarum (DC.) Arth. & Jacks.

On Veronica serpyllifolia L. Ames: Pammel 1892.

On Veronica virginica L. (Leptandra virginica (L.) Nutt.) (16. 25, 31, 32, 53). Ames: Bessey 1878; Bettenga 1892; Carver 1892; Stewart 1892. Decorah: Holway 1885**; 1886 (Arth. & Holw, Ured, Exsic. 9a): 1892 (Ibid. 9b). Winneshiek Co.: Goddard 1895.

Puccinia verrucosa (Schultz) Wint. — Puccinia hyssopi.

654. Puccinia vexans Farl. (25, p. 320)

Syn. Dicaeoma vexans (Farl.) Kuntze.

On Bouteloua sp. Decorah: Holway 1890**.

On Bouteloua curtipendula (Michx.) Torr. (16, 25, 31, 34, 53, 352), Ames: Bessey 1882; Carver 1895; Pammel 1890 (Seym. & Earle Econ. Fung. 532b), Ibid.* Decorah: Holway ---; 1885 (Arth. & Holw, Ured, Exsic. 58e); (Ellis N. Amer. Fung. 1051), Ibid.*; 1890**.

Arthur (16) reported this rust on Sporobolus cuspidatus Wood in his first list but subsequently (31) he reported the rust on that host as Puccinia

sporoboli.

655. Puccinia violae (Schum.) DC. (25, p. 392)

Syn. Dicaeoma violae (Schum.) Kuntze.

On Viola sp. Ames: Bessey 1878. Ledges-Boone: Archer 1927 (Survey 631). West Union: Archer and Layton 1927 (Survey 762).

On Viola cucullata Ait. (16). Ames: Halsted 1886**. Decorah: Holway 1881; 1882*; 1888**. Winneshiek Co.: Goddard 1895.

On Viola eriocarpa Schw, (25, 31).

On Viola obliqua Hill. Decorah: Holway 1885 (Barth. N. Amer. Ured. 975), Ibid.*

On Viola papilionacea Pursh. (25, 31, 522).

On Viola pubescens Ait. (16, 25, 31, 522). Ames: Hitchcock 1885-86. Decorah: Holway 1882 (Ell. N. Amer. Fung. 1007), Ibid.*; 1886 (Barth. N. Amer. Ured. 974), Ibid.*; 1887*. Marion Co.: Pammel 1921. Montour: Conard 1923**.

On Viola scabriuscula Schw. (522). Traer: Pammel 1923.

On Viola sororia Willd. (25, 31).

656. Puccinia xanthii Schw. (25, p. 571)

Syn, Micropuccinia xanthii (Schw.) Arth. & Jackson.

On Xanthium canadense Mill. (16, 31, 32, 53, 368, 380). Ames:
Carver 1895; Hodson 1899; Pammel 1898; Stewart 1893,
1894. Boone: Coe 1912. Columbus Jct.: Hume 1899; Pammel 1898, 1899. Decatur Co.: Anderson 1904. Decorah:
Holway 1889 (Arth. & Holw. Ured. Exsic. 10c), (Syd. Ured.
487). Des Moines: Pammel 1894. Jefferson: Pammel 1895.
Turin: Pammel 1894.

On Xanthium commune Britton. Winterset: Leach 1926.

On Xanthium echinatum Murr. Ames: Bessey 1878. Decorah: Holway 1881*. Waterloo: Bartholomew 1919 (Barth. N. Amer. Ured. 2277).

On Xanthium italicum Mor. (25, 31).

657. Puccinia xanthiifoliae Ell. & Ev. (25, p. 419)

Syn. Dicaeoma xanthiifoliae (E. & E.) Arth.

On Iva xanthifolia Nutt. (368). Mondamin: Archer 1927 (Survey 1249). Onawa: Pammel 1894.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 2252a.

Orton (336a p. 204) cites this exsiccatum as *Puccinia intermixta* Pk., but Arthur (25, p. 419) and Sydow (486) eite it as *Puccinia xanthiifoliae*. *Puccinia zygadeni* Trel. = *Puccinia atropuncta*.

658. Pucciniastrum agrimonae (Schw.) Tranz. (25, p. 106)

On Agrimonia gryposepala Wallr. (Agrimonia eupatoria Michx., Agrimonia hirsuta (Muhl.) Bickn.) (16, 25, 31, 410, 522). Ames: Bessey 1875, 1877; Halsted 1885**; Hume 1899; Pammel 1892. Decatur Co.: Anderson 1904. Decorah: Holway 1885**. Lake Mills: Pammel 1918. Story City: Archer and Layton 1927 (Survey 675).

On Agrimonia mollis (T. & G.) Britt. (Eupatorium mollis (T. & G.) Britt.) (25, 31, 522).

659. Pucciniastrum americanum (Farl.) Arth. (25, p. 677)

On Rubus idacus var. aculeatissimus (Mey.) R. & T. (Rubus strigosus) (10, 25, 31). Decorah: Holway 1884 (Barth. N. Amer. Ured. 482). Ibid.*

660. Pucciniastrum pustulatum (Pers.) Dietel. (25, p. 107)

On Epilobium coloratum Muhl. (25, 31). Ames: Carver 1892. Decorah: Holway 1886 (Barth. N. Amer. Ured. 978), Ibid.*

661. Pucciniastrum pyrolae (Pers.) Dietel. (25, p. 108) On Pyrola elliptica Nutt. (25, 31, 522).

662. Pyrenopeziza medicaginis Fekl. (256)

On Medicago sativa L. (alfalfa) (15, 256). Ames: Hughes 1923. Sac City: Archer 1927 (Survey 704).

663. Pyrenophora teres (Diedicke) Drechsler (106)

Syn. Helminthosporium teres Sacc.

On Hordeum vulgare L. (cult. barley) (15, 191, 406). Ames: King 1912, 1914.

664. Rabenhorstia tiliae Fr. (103)

On Tilia americana L. (cult. basswood) (15). Shenandoah: Bliss 1927 (Survey 1679).

Exsic. eited: Thum. Myc. univ. 492; Ell. & Ev. N. Amer. Fung. 2952.

665. Ramularia sp.

On Amaranthus retroflexus L. Waukon: Pammel 1908**.

Spores are one-celled, hyaline, spindle-shaped, $10-16\mu$ long. The leaf spot resembles that caused by Cercospora brachyiata E. & E.

666. Ramularia actaeae Ell. & Holw. (128)

On Actaea alba L. (128).

667. Ramularia aequivoca (Ces.) Sacc. (294)

Svn. Ramularia gibba Fekl. .

On Ranunculus septentrionalis Poir. (199). Ames: Halsted 1887 (Ell. & Ev. N. Amer. Fung. 2nd Ser. 1983).

This was reported on Ranunculus repens L.

668. Ramularia armoraciae Fckl. (128)

On Radicula armoracia (L.) Robinson (199, 522). Ames: Hitchcock 1885-86. Fayette: Wilson 1909 (Wilson & Seaver Ascom. & Low. Fung. 94).

On Radicula palustris (L.) Moench. (199).

669. Ramularia arvensis Sacc. (435)

On Potentilla monspeliensis L. (199, 522). Ames: Anderson 1913; Carver 1892; Hitchcock 1885-1886; Raymond 1891. Conesville: Archer 1927 (Survey 940). Osceola: Archer 1927 (Survey 892). Exsic. cited: Ell. N. Amer. Fung. 1240; Ell. & Ev. Fung. Col. 1359;

Seym, & Earle, Econ, Fung. 280.

Cited by Gilman (189) as Mycosphaerella fragariae. The connection with Mycosphaerella has not been made for the Ramularia on Potentilla.

670. Ramularia asteris (Plowr. & Phill.) Bub. (61, 90, 128, 292, 294, 428)
Syn. Ramularia filaris Fres. forma astericola Sace., Ramularia macrospora Fres. var. asteris Trel., Ramularia asteris (Trel.) Barth.,
Fusidium (?) asteris Plowr. & Phill., Ramularia asteris tripoli
Jaap.

On Aster sp. Decorah: Holway 1884.

On Aster novae-angliae L. Decorah: Holway 1885.

Exsic. cited: N. Amer. Fung. 1532; Barth. Fung. Col. 2679, 3472, 4069.

The synonomy of this fungus is again listed in order to bring together the decisions of various workers, no one of whom has given a complete synonomy.

671. Ramularia astragali Ell & Holw.

On Astragalus canadensis L. (128, 154). Decorah: Holway 1884 (type).

Ramularia cana Sacc. = Cercosporella cana.

672. Ramularia celastri E. & M. (128)

On Celastrus scandens L. (199). Ames: Carver 1892. Decorah: Holway 1884. Story City: Hume 1899.

Exsic. cited: Barth. Fung. Col. 3376.

673. Ramularia concomitans Ell. & Holw. (136)

On *Bidens sp.* (136). *Decorah:* Holway 1885 (Ell. & Ev. N. Amer. Fung. 2nd Ser. 1521).

The same fungus appears as Septocylindrium concomitans (Ell. & Holw.) Halst. in Seymour and Earle, Ec. Fung. 299.

674. Ramularia decipiens E. & E. (126, 128)

On Rumex crispus L. (199).

On Rumex verticillatus L. (199).

675. Ramularia desmodii Cooke (128)

Syn. Fusidium ravenelianum Thüm.

On Desmodium sp. (128).

On Desmodium canadense (L.) DC. Ames: King 1910. Decorah: Holway 1884 (Rabenhorst-Winter, F. europ. 3579a; Ell. & Ev. N. Amer. Fung. 1526). Conesville: Archer 1927 (Survey 974).

Exsic. cited: Ell. & Ev. N. Amer. Fung. 656; Ell. & Ev. Fung. Col. 1583; Barth. Fung. Col. 2784, 2785; Rabenhorst-Winter, F. eur. 3579b; Thüm. Myc. univ. 1970; Ravenel F. Amer. 62, 582.

In the Iowa specimen, (Survey 974) the fructification was entirely different than that found in the specimens and exsiccati cited. Instead of the usual sparse, scattered and inconspicious tufts of conidiophores there occurred extensive confluence of the fruiting hyphae. These sometimes formed large, irregular zigzag patterns on both surfaces of the leaf. Also there was noticeable hypertrophy of the tissues. The spores were a microtype and not of the kind described in the literature for the species. In fact, the usual "macrospore" did not occur; instead they were found to be extremely small, $6.8 \times 3.4\mu$ and oval.

At first the microspore was thought to be merely a young stage of the macrospore but careful scrutiny did not bear out the idea. The microspore does not possess the characteristic scar at the base, as found in the larger spores, indicating the point of attachment to the conidiophore. From all appearances these microspores are borne in chains; the usual geniculate conidiophore was not visible. Evidently the spore chains arise directly from the mycelium.

A careful examination of the exsiccati reveals the presence of the microspores, which are mixed with macro type. This was true in the Iowa collections, Holway 1884 (also the example in Rabenh.—Winter 3579a); King 1910 and in Fung. Col. 1583 (two examples examined); Fung Col. 2784; Rabenh.—Winter 3579b; and Ravenel 582. In Thümen Myc. univ. 1970; Fung. Col. 2785; N. Amer. Fung. 656 only the macrospores occurred.

In the literature the macrospores are described as $12-24 \times 3.5-4\mu$ (Ellis & Everhart (128) and $20-24 \times 3.5-4.5\mu$ (Thümen (495)). However, the present study of the exsiccati indicates a variation in the spore size of $10-34 \times 3.4-6.8\mu$. The smallest of these macrospores (10×3.4) are commonly pyriform with a scar or sometimes a small stipe at the lower end, indicating the point of attachment to the conidiophore. As already men-

tioned, this scar or stipe does not occur on the microspore.

Presumably the existence of the microspore has not been noted before in the literature. The existence of these as a secondary type of fruiting together with the nature of the parasitism seen in the Iowa specimen. (Survey 974) is a certain indication that this fungus is not a true Ramularia. It resembles closely Hymenula affinis (Faut. & Lamb.) Wr. (Wollenweber (539) and Sherbakoff (452)). However, it will be retained under its present name until more extensive studies can be made.

Ramularia didyma Ung. = Didymaria didyma

676. Ramularia evonymi (Ellis & Kellerman) emended. (92, 124, 157) Syn. Cercospora evonymi Ell., Ramularia evonymi Ell. & Kell., Cercosporella evonymi Eriks.

On Evonymus atropurpureus L. Decorah: Holway 1884. Decatur Co.: Anderson 1902. Ledges—Boone: Anderson 1913;
Archer 1927 (Survey 623)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1245; Barth. Fung. Col. 2211.

Judging from the examination of the exsiccati and the Iowa collections cited, the spores of this fungus are quite variable. They may be oblong-cylindrical and one-celled to obclavate-cylindrical and several celled. All variations between the two extremes are to be found. The measurements are variable $(20\text{-}65 \times 3\text{-}8\mu)$. Also they may be borne either singly or in chains, acro- or pleurogeneously on the hyaline conidiophores. The fasiculate conidiophores arise from a tuberculate base below the cuticle. The fragility of the spore chains prevents a ready transfer for microscopic examination. However, their catenulate nature is easily determined from the presence of a hilum at either end, and besides the examination of fresh material reveals an occasional short chain consisting of two or three spores. The catenulate nature of the spores was distinctly visible in the example of $Cercospora\ evonymi$ in N. Amer. Fung. 1245.

Since the original descriptions of both Cercospora evonymi Ell. and Ramularia evonymi E. & K. were inadequate it has been deemed best to combine the two under the emended name of Ramularia evonymi Ell. &

Kell.

Although no specimens were seen of *Cercosporella evonymi* Eriks., yet the description (428, v. 10, p. 564) leaves no doubt as to the true nature of the fungus.

677. Ramularia filaris Fres. (128)

On *Aster sp.* (128)

Ramularia gibba Fckl. = Ramularia aequivoca (Ces.) Sacc.

678. Ramularia heraclei (Oud.) Sacc. (128)

On Heracleum lanatum L. Ames: Hitchcock 1885-86; Hume & Hodson 1899.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1241; Ell. & Ev. Fung. Col. 1273, 1584; Barth. Fung. Col. 3774, 4070; Krieger, F. sax. 1292.

679. Ramularia impatientis Pk. (128)

On Impatiens biflora Walt. Indianola: Archer 1927 (Survey 1099) On Impatiens pallida Nutt. Oclwein: Archer 1927 (Survey 759) Exsic, cited: E. & E. N. Amer, Fung. 1773; Ell. & Ev. Fung. Col. 89.

680. Ramularia macrospora Fres. var. asteris Trel. (122) On Aster novae-angliae L. (199)

681. Ramularia plantaginis E. & M. (128)

On Plantago sp. Cedar Rapids: Archer 1927 (Survey 604)

On Plantago major L. (199). Ames: Carver 1894; Archer 1927 (Survey 1322). Hudson: Archer & Layton 1927 (Survey 772). Humboldt: Archer 1927 (Survey 1233)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1243; Ell. & Ev. Fung. Col. 690: Barth. Fung. Col. 3274, 3377.

682. Ramularia pratensis Sacc. (428, v. 4, p. 215) On Rumex britannica L. (199)

683. Ramularia ranunculi Pk. (128)

On Ranunculus abortivus L. (199) 684. Ramularia rudbeckiae Pk. (396, p. 47)

On Rudbeckia laciniata L. (522). Decorah: Holway 1885**.

685. Ramularia subrufa Ell. & Holw. (136) On Smilax sp. (136)

686. Ramularia taraxaci Karst. (435; 428, v. 4, p. 207)

On Taraxacum erythrospermum Andrz. Cedar Rapids: Archer 1927 (Survey 611)

On Taraxacum officinale Weber. (199, 522). Ames: King 1911. Emmetsburg: Archer 1927 (Survey 1354)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 2872; Ell. & Ev. Fung. Col. 87.

Ramularia tulasnei Sacc. — Mycosphaerella fragariae

687. Ramularia urticae Ces. (128)

Exsic. cited: Allescher & Schn. Fung. bavar. 395.

688. Ramularia variabilis Fckl. (128)

On Verbascum sp. Decorah: Holway 1885.

On Verbascum thapsus L. (199)

Rheosporangium aphanodermatum Edson = Aphanomyces raphani

689. Rhizoctonia bataticola (Taub.) Butler (454)

Syn. Sclerotium bataticola Taub.

On Ipomoea batatas Lam. (406)

Rhizoctonia betae - Corticum vagum B. & C.

690. Rhizoctonia crocorum DC. (108)

On Medicago sativa L. (104, 168, 376)

Rhizoctonia medicaginis DC. = Rhizoctonia crocorum

Rhizoctonia solani = Corticium vagum B. & C.

691. Rhizopus nigricans Ehr. (288)

On Fragaria sp. (cult. strawberry) (406)

On Ipomoea batatas Lam. (sweet potato) (15). Ames: Larson 1899.

On Prunus americana Marsh. (361)

On Solanum tuberosum L. (potato) (410)

692. Rhynchosporium secalis (Oud.) Davis (294) Syn, Rhynchosporium graminicola Heinsen,

On Hordeum vulgare L. (406)

Rhysotheca halstedii (Farl.) Wils. = Plasmopara halstedii

Rhysotheca viticola (B. & C.) Wilson = Plasmopara viticola

693. Rhytisma acerinum (Pers.) Fr. (435)

On Acer sp. (53, 341)

On Acer saccharinum L. (Acer dasycarpum) (8, 197, 522). Ames:
Bessey 1882; Carver 1896**; Hitchcock 1885-86; Hume 1899.
Decatur Co.: Anderson 1904. Storm Lake: Pammel 1913.

694. Rhytisma asteris Schw. (428, v. 8, p. 763)

695. Rhytisma punctata (Pers.) Fr. (428, v. 8, p. 753) On Acer saccharum Marsh. Muscatine: Merrill 1915.

696. Rhytisma salicinum (Pers.) Fr. (428, v. 8, p. 753) On Salix sp. Ames: Carver 1896**.

697. Rhytisma solidaginis Schw. (428, v. 8, p. 763)

On Aster cordifolius L. (522)

On Solidago graminifolia (L.) Salisb. (522)

On Solidago latifolia L. (522)

Roestelia lacerata Fr. = Gymnosporangium juniperi-virginianae Roestelia penicillata Fr. = Gymnosporangium juniperi-virginianae Roestelia pyrata Thaxt. = Gymnosporangium juniperi-virginianae

698. Sacidium abietis Oud. (428, v. 16, p. 992) On Abies sp. Decorah: Holway 1882.

699. Schizonella melanogramma (DC.) Schröt. (74, p. 36)

On Carex sp. (380)

On Carex pennsylvanica Lam. (72, 74, 245, 522). Ames: Carver 1896**; Melhus 1924. Beaver: Pammel 1901¹. Boone: Pammel 1913. Decorah: Holway 1899. North Liberty: Martin 1925**.

On Panicum miliaceum L. (10)

700. Sclerospora graminicola (Sacc.) Schröt. (322)

On Euchlaena mexicana Schrad. (teosinte) (321) On Holcus sorghum L. (cult. sorghum) (322)

On Panicum miliaceum L. (321)

On Setaria glauca (L.) Beauv. (Chaetochloa lutescens (Weigel) Stuntz) (406, 522)

Artificial infection not secured on this host by workers in laboratory, Iowa State College.

¹Fide—G. P. Clinton.

On Setaria italica (L.) Beauv. (299, 321, 352, 389, 410, 520)

On Setaria viridis (L.) Beauv. (197, 202, 299, 321, 322, 352, 366, 368, 376, 389, 410, 520, 522). Ames: Combs 1894; Crane 1896; Melhus 1916; Pammel 1890; (U. S. D. A. Div. Veg. Phys. & Path.) (Seym. & Earle Econ. Fung. 64); Halsted 1886 (Ell. & Ev. N. Amer. Fung. 2nd Ser. 1803). Jefferson: Pammel 1895. Kossuth Co.: Pammel 1897. Steamboat Rock: Pammel, 1901. Turin: Pammel 1895.

On Zea mays L. (10, 321, 322). Ames: Layton 1927. On Zea mays var. everta Bailey (cult. pop corn) (321)

On Zea mays var, rugosa Bonaf, (sweet corn) (15), Ames: Layton 1927 (Survey 900)

The specimen on Zea mays was from the experimental plots of the Plant Pathology Section of the Iowa Experiment Station on soil artificially infested with oospores from Setaria.

701. Sclerotinia angustior (Sacc.) Reade (415)

On Prunus virginiana L. (10, 522). Ames: Gilman 1928 (Survey 1712)

Sclerotinia crataegi Magn. = Sclerotinia johnsoni Sclerotinia fructigena - Sclerotinia fructicola

702. Sclerotinia fructicola (Wint.) Rehm. (242)

On Prunus spp. (cult. cherry) (15, 341)

On Prunus spp. (cult. plum) (15, 191, 340, 341, 406)

On Prunus sp. Ames: Brownlie 1893. Avon: Lang 1909. Breda: Gunn 1908. Indianola: Jenner 1908. Osterdock: Stewart 1915. Pocahontas: Kronek 1915.

On Prunus americana L. (8, 361, 368, 380, 383, 522). Boone: Anderson 1913; Coe 1912. Hawarden: Pammel 1902.

On Prunus besseyi Bailey (sand cherry, Rocky Mt. dwarf cherry) (15). Independence: Nichols 1927 (Survey 1052)

On Prunus cerasus L. (cherry) (15, 191)

On Prunus domestica L. Ames: Pammel 1893. On Prunus hortulana Bailey (8, 189)

On Prunus persica (L.) Stokes (cult. peach) (8, 15). Muscatine: Hiller 1908**.

On Prunus pumila L, x hortulana mineri Bailey (compass cherry)

On Prunus salicina Lindl. (8). Ames: Pammel 1897.

On Pyrus malus L. (apple) (406)

Honey (242) has suggested the name Monilinia for the section of the genus Sclerotinia containing the forms related to Sclerotinia fructicola, but the authors have retained the old name because of its common usage. 703. Sclerotinia gregaria Dana (84, 415)

On Amelanchier canadensis L. Ames: Gilman 1924.

Two species of Sclerotinia have been described from Amelanchier: one on the fruit from New York, and the other on leaves and fruit from Washington. Our specimen corresponds with the latter, being on young leaves and having the smaller conidia that Dana (84) describes.

704. Sclerotinia johnsoni (E. & E.) Rehm. (415, 420)

Syn. Monilia crataegi Died.

On Crataegus margaretta Ashe. Westfield: Conard 1926 (Survey 598)

On Crataegus mollis (T. & G.) Scheele. Ames: Berkhout 1924. Exsic, eited: Barth. Fung. Col. 4440.

705. Sclerotinia libertiana Fckl. (540)

On Helianthus annuus L. (255, 354, 406)

On Lactuca sativa L. (470)

Young and Morris (540) have raised the question as to the correct name for this fungus. Sclerotinia libertiana Fckl. has been rather commonly accepted. Wakefield (505) considers the name Sclerotinia sclerotiorum (Lib.) Massee to have priority as published in British Fungus Flora Vol. IV (1895). However, an examination of Cohn Kryptogamen—Flora von Schleisen, Dritte Band, Zweite Hälfte, Erste Lieferung (1893) shows that the combination Sclerotinia sclerotiorum (Lib.) Schroet. has a priority of two years over that of Massee. For the purposes of this paper, however, the authors prefer the usage of Sclerotinia libertiana Fckl. 706. Sclerotinia seaveri (Reade) Rehm (415)

On Prunus serotina Ehrh. Iowa City: Seaver 1905 (Rehm Ascomyceten 1633)**

707. Sclerotinia tuberosa (Hedw.) Fekl. (428, v. 8, p. 195)

On Anemone quinquefolia L. (522)

Sclerotium bataticola Taub. = Rhizoctonia bataticola

708. Sclerotium delphinii Welch (485)

On Delphinium sp. (cult.). Ottumwa: Porter 1928 (Survey 1717)

709. Sclerotium gladioli Massey (310)

On Gladiolus sp. (cult.). Ames: Evans 1929.

710. Scoleconectria scolecospora (Bref.) Seaver (442)

On Pinus sylvestris L. (probably P. instititia L.). Ames: Van Haltern 1924.

This specimen was cited by Gilman (189) as Cenangium abietis, but re-examination has proved it to be the above species.

711. Scolecotrichum graminis Fckl. (468)

On Alopecurus geniculatus L. Galt: Archer 1927 (Survey 1230)

On *Dactylis glomerata* L. (352, 389). *Ames*: King 1910; Pammel 1909; Stewart 1893.

On Elymus canadensis L. Ames: Pammel 1891.

On Hordeum vulgare L. (361)

On Muhlenbergia mexicana (L.) Trin, (522)

On Phleum pratense L. (cult. timothy) (15, 389). Decatur Co.: Anderson 1900. Dunbar: Archer 1927 (Survey 787). Forest City: Bakke 1909.

On Poa compressa L. Ames: Gilman 1929.

Scolecotrichum iridis Fautr. & Roum. = Didymellina iridis

712. Septocylindrium rufomaculans (Peck) Pound & Clements (128)

Syn, Ramularia rufomaculans Pk.

On Polygonum aviculare L. (522). Ames: Archer 1927 (Survey 1710). Fayette: Wilson 1909 (Wilson & Seaver Asco. & Low. Fung. 97)

On Polygonum dumetorum L. (199)

On Polygonum muhlenbergii Wats. Ames: Carver 1892.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1533; Barth. Fung. Col. 3680, 4473.

Septogloeum acerinum (Pass.) Sacc. — Septoria aceris Septogloeum ampelopsidis (Ell. & Ev.) Sacc. — Septoria ampelopsidis Septogloeum apocyni Pk. — Cylindrosporium apocyni Septogloeum fraxini Harkn. — Cylindrosporium fraxini Septoria acerina Pk. — Septoria aceris

713. Septoria aceris (Lib.) Berk. & Br. (230)

Syn. Ascochyta aceris Lib. (Höhnel 230, p. 62; Laibach 288b, p. 179), Cylindrosporium acerellum (Sacc.) Died. (Diedicke 102, p. 486; Laibach 288b, p. 179), Cylindrosporium acerinum Tracy & Earle (Dearness 97, p. 164; 98, p. 71; Höhnel 230, p. 76), Cylindrosporium canadense Bubak & Dearness (Dearness 98, p. 72), Culindrosporium consociatum Dearn. (Dearness 97, p. 172; 98, p. 72), Cylindrosporium negundinis E. & E. (Höhnel 230, p. 76), Cylindrosporium pennsylvanicum E. & E. (Dearness 98, p. 74), Cylindrosporium platanoides (All.) Died. (Diedicke 102, p. 486; Laibach 288b, p. 179), Cylindrosporium pseudoplatani (Rob. & Desm.) Died. (Diedicke 102, p. 486; Laibach 288b, p. 179), Cylindrosporium saccharinum E. & E. (Höhnel 230, p. 62; Davis 88, p. 80; Dearness 98, p. 74), Gloeosporium acericolum All. (Höhnel 230, p. 68), Glocosporium acerinum West. (Höhnel 230, p. 68), Glocosporium campestre Pass. (Höhnel 230, p. 68), Hendersonia californica (E. & E.) Höhn., (Höhnel 230, p. 74), Marssonia acerina (West.) Bres. (Höhnel 230, p. 68), Phleospora acerina (Pass.) Petr., Phleospora aceris (Lib.) Sacc. (Diedicke 102, p. 486; Höhnel 229, p. 87; Laibach 288b, p. 179), Phleospora californica (E. & E.) (Höhnel 230, p. 74), Phleospora canadense Bubak (Dearness 98, p. 72), Phleospora curvispora (E. & E.) Petr. (Dearness 97, p. 164; 98, p. 72), Phicospora platanoides Bub. & Kab. (Höhnel 230, p. 71), Phleospora platanoides (All.) Petr. (Laibach 288b, p. 180), Phleospora pseudoplatani Bub. & Kab. (Höhnel 230, p. 71), Phleospora samarigena Bub. & Krieg. (Höhnel 230, p. 71), Phleosporella acerina (Pk.) Höhn. (Höhnel 230, p. 75), Phyllosticta minutissima E. & E. (Davis 90, p. 71; Dearness 97, p. 172; Dearness & House 100, p. 83; Keissler 269, p. 20-21), Phyllosticta platanoides Sacc. (Höhnel 230, p. 73), Phyllosticta tamboriensis B. & S. (Höhnel 230, p. 73), Septogloeum acerinum (Pass.) Sacc. (Höhnel 230, p. 70; Laibach 288b, p. 179; Petrak 403, p. 168-169), Septogloeum hercynicum Syd. (Höhnel 230, p. 72; Diedicke 102, p. 486), Septomyxa acerina (W.) Höhn. (Höhnel 230, p. 68; Petrak 403, p. 10-14), Septoria acerella Sacc. (Davis 92, p. 282; Diedicke 102, p. 486; Höhnel 230, p. 486; Laibach 288b, p. 179), Septoria acerella Sacc. var. major Brun. (Höhnel 230, p. 70), Septoria acerina Pk. (Davis 90, p. 172; Dearness 98, p. 71; Höhnel 230, p. 75), Septoria acerina Sace. (Laibach 288b, p. 179), Septoria aceris-macrophylli Pk. (Höhnel 230, p. 75), Septoria apetala All. (Diedicke 102, p. 486; Höhnel 230, p. 72; Laibach 288b, p. 180), Septoria circinata E. & E. (Höhnel 230, p. 75; Dearness 97, p. 164), Septoria curvispora E. & E. (Dearness 97, p. 164; Höhnel 230, p. 75), Septoria epicotylea Sacc. (Diedicke 102, p. 486; Höhnel 230, p.

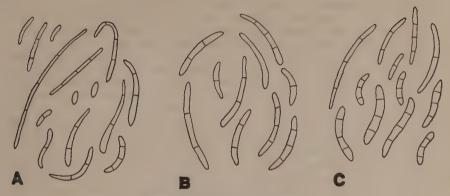


Fig. 2. Variability of spores.

A. Septoria acerina Pk.; Iowa Survey 1699 (8-58 x 2-4.2μ)

B. Septoria marginata Heald & Wolf; Heald & Wolf 2286 (27-40 x 3.5-4μ)

C. Pleospora acerina (Pass.) Petr.; Petrak, Fungi polonici 109 (11.5-40 x 3-5.8µ)

71; Laibach 288b, p. 179), Septoria incondita Desm. (Diedicke 102, p. 486), Septoria incondita Desm. var. acericola Desm. (Höhnel 230, p. 71; Laibach 288b, p. 179), Septoria macrophylli E. & E. (Höhnel 230, p. 75), Septoria marginata Heald & Wolf (Heald and Wolf 211, p. 59-60), Septoria negundinis E. & E. (Höhnel 230, p. 74; Davis 92, p. 282), Septoria platanoides (All.) Laibach (Laibach 288b, p. 180), Septoria pseudoplatani Rob. & Desm. (Diedicke 102, p. 486; Höhnel 230, p. 69; Laibach 288b, p. 179), Septoria saccharina E. & E. (Davis 88, p. 80; Höhnel 230, p. 76), Septoria saccharina E. & E. var. occidentalis E. & E. (Höhnel 230, p. 76), Septoria samarae Peck (Höhnel 230, p. 76), Septoria samarigena Bub. & Krieg. (Diedicke 102, p. 486; Laibach 288b, p. 180), Septoria schirajewshii Bub. & Sereb. (Höhnel 230, p. 72), Septoria seminalis Sacc. (Diedicke 102, p. 486; Laibach 288b, p. 179), Septoria seminalis Sacc. var. platanoides All. (Diedicke 102 p. 486; Höhnel 230, p. 70; Laibach 288b, p. 180), Stictochorella platanoides (Sacc.) Höhn. (Höhnel 230, p. 71) On Acer sp. Shenandoah: Archer 1926 (Survey 1701)

On Acer dasycarpum pyramidale Hort. (cult. pyramidal silver maple) (15). Shenandoah: Bliss 1927 (Survey 1695) (11-

 $22 \times 3.9 - 4.5 \mu$

On Acer negundo L. (cult. boxelder) (15, 199). Shenandoah: Bliss 1927 (Survey 1647, 1696 and 1697) (15-36 x 2-4 μ)

On Acer platanoides L. (cult. Norway maple) (15). Shenandoah:

Bliss 1927 (Survey 1700) (19-60 x 3.5μ)

On Acer platanoides var. schwedleri Koch. (cult. Schwedler maple) (15). Shenandoah: Bliss 1927 (Survey 1699) 8-58 x 2-4.2\mu)

On Acer saccharinum var. weiri Schwer. (cult. Weir maple).

Shenandoah: Bliss 1927 (Survey 1698)

Exsic. cited: Ascochyta aceris Lib.: Libert—Pl. Crypt. Ard. 54 (34-46 x 2-3μ). Cylindrosporium negundis E. & E.: Ell.

& Ev. N. Amer. Fungi 3075; Ell. & Ev. Fung. Col. 448; Bartholomew Fung. Col. 3075. Gloeosporium acericolum All.: Vogel—Flora der mark 7-8 x 3.5μ (15-30 x 3.9μ), Gloeosporium acerinum West: Thüm. Myc. univ. 93 (spores measure 30 µ long, but literature always cites 20 µ for this exsiccati). Phleospora acerina (Pass.) Petrak: Petrak Fungi polonici 109 (11.5-40 x 3.5-5.5μ). Pleospora aceris (Lib.) Sacc.: Allescher & Schnabl—Fungi bay. 679 (no spores seen); Bartholomew—Fung. Col. 2247 (22-35 x 3.5-4.5μ); Ell. & Ev. N. Amer. Fungi 2284; Ell. & Ev. Fung. Col. 1059; Kabat & Bubak—Fungi imperfecti 175 (15-31 x 4-4.5 μ); Krieger—Fungi Sax, 450, 991 (27-59 x $3.5-4\mu$); Rabenh.— Wint.—Fungi Europ. 3480; Seymour & Earle—Econ. Fungi 108 (20-40 x 3.5-4.5μ); Underwood & Cook—Illust, Fungi 75; U. S. D. A., Div. Veg. Phys. & Path. 537, 1165 (19-40 x 3-4.5). Phleospora californica E. & E.: Ell. & Ev. Fung. Col. 852 (25-30 x 3-5 μ). Phyllosticta minutissima E. & E.: Barth.— Fung. Col. 2251, 3735, 4340. Septogloeum acerinum (Pass.) Sacc.: Ell. & Ev.—Fung. Col. 1585: Petrak—Flora Boh. & Mor. 927 (19-47 x 3.5-4.3 μ); Sydow—Myc. germ. 1275 (19-31 x 3.5-4.3µ). Septoria acerina Pk.: Ell. & Ev.—N. Amer. Fungi 625 (20-47 x 2.5-4\mu); Ell. & Ev. Fung. Col. 142; Barth. -Fung. Col. 2374; Farlow Herb. Sept. 1913; Weir Herb. 16560 (30-70 x 2.5-3.5μ). Septoria aceris (Lib.) Berk. & Br.: Petrak—Fl. Boh. & Mor. 1774 (24-78 x 3.5-5μ); Myc. carp. 370 $(25-43 \times 3.7-4.2\mu)$; Rabenhorst—Fung. Europ. 2157; Sydow.—Myc. march, 1000 (no spores seen); Myc. germ. 2197 (27-47 x 3.6-4.3); Thüm.—Myc. univ. 1092 (15-31 x 4-4.5µ). Septoria aceris-macrophylli Peck: Barth.—Fung. Col. 4874 (25-52 x 2.5-3.9 μ). Septoria circinata E. & E.: Ell. & Ev.—Fung. Col. 974; Barth.—Fung. Col. 4477 (20-40) x 1.5-3); Clements—Crypt, Form, Col. 54 (20-60 x 2-4 μ); Ell. & Ev.—N. Amer. Fung. 3368 (20-45 x 1.5-3μ); Ell. & Ev. Fung. Col. 1780 (20-58 x 1.5-4 μ); Sydow Fungi exotici 746 $(20-45 \times 1.5-3\mu)$. Septoria curvispora E. & E. Ell. & Ev. N. Amer. Fung. 3270 (20-47 x 1.5- 2.5μ). Septoria marginata Heald & Wolf: Heald & Wolf 2286 (27-40 x 3.5-4\mu). Septoria negundinis E. & E.: Ell. & Ev.—N. Amer. Fung. 2859 $(34-48 \times 3\mu)$. Septoria saccharina E. & E.: Ell. & Ev.—N. Amer. Fungi 2652; 2951 (20-47 x 1.5-2\mu); House, New York in 1920 (20-55 x 1.5-3.9μ). Septoria samarae Pk.: Barth.— Fung. Col. 3387 (20-47 x 2.4μ)

The above synonomy resulting from examination of the literature and exsiccati combines under the species, *Septoria aceris*, various species considered distinct by different workers (Diedicke 102; Höhnel 230; Laibach 288b, and others). Most of the European workers agree upon three species of Septoria on Acer distinguished by host or by spore length. Inoculations between hosts failed when attempted by Laibach (288b); however, he states definitely (288b, p. 127) that such negative results are not to be

given undue importance since re-inoculations upon the original host plant by no means met with uniform success.

Incidentally Laibach (288b) demonstrated definitely the connection of a Septoria occurring upon Acer pseudoplatanoides with a perfect stage which he called Mycosphaerella latebrosa (Cooke) Schroeter. (Cfr. also Höhnel (230)). The present authors, in light of their extensive lumping of synonomy, do not feel justified in accepting, as yet, this perfect stage without further investigation.

The comparison of the freshly collected Iowa material with the cited exsiccati demonstrates the impossibility of separating species on the basis of spore size or shape. (See text fig. 2; also Davis (88, p. 80-81; 92, p. 282)). Likewise the absence or presence of a pyenidial wall is obviously controlled by the physiological environment. (See discussion under Cylindrosporium). This perhaps holds true for the supposed characteristic modes of spot formation to be seen in various collections. In Iowa material some leaves were marked by well-defined spots, but in others the infected areas were diffuse and involved considerable or irregular leaf portions.

714. Septoria agrimoniae eupatorii Bomm. & Rous. (428, v. 10, p. 363) On Agrimonia mollis (T. & G.) Britton (8, 522)

715. Septoria agropyri E. & E. (512)

On Agropyron repens (L.) Beauv. Lytton: Archer & Layton 1927 (Survey 698). Storm Lake: Archer 1927 (Survey 715).

Exsic. cited: Davis F. Wis. 60. 716. Septoria alismatis Oud. (305)

On Alisma plantago-aquatica L. (305, 502)

717. Septoria ampelina B. & C. (305)

On Vitis vulpina L. (502). Ledges—Boone: Coe 1912.

Exsic. cited: Ravenel, F. Amer. 29; Ellis N. Amer. Fung. 623; Thüm. Myc. univ. 1185; Herb. U. S. D. A. 1166.

This specimen was reported by Uppal (502) under the host Vitis vinitera L.

718. Septoria ampelopsidis Ellis (62, 91)

Syn. Septogloeum ampelopsidis (E. & E.) Sacc.

On Psedera quinquefolia (L.) Greene (Ampelopsis quinquefolia Michx.). Ames: Stewart 1892 (Ell. & Ev. N. Amer. Fung. 2nd Ser. 3387)

On Psedera tricuspidata Hort. (Ampelopsis tricuspidata Sieb. & Zucc.) (Parthenocissus tricuspidata Planch.) (cult. Boston ivy) (15). Shenandoah: Bliss 1927 (Survey 1015 and 1633)

The spores are hyaline, with attenuated ends, many-celled, 40-60 x 3.5-6.8 μ ; sometimes issuing out in white masses which stain the surface of the leaf. Bubak (62) changed this fungus to *Phleospora ampelopsidis* (E. & E.) Bub.

719. Septoria anemones Desm. (103)

On Anemone canadensis L. Jefferson Co.: Smith 1927 (Survey 579a) On Anemone virginiana L. (502). Decorah: Holway 1885.

720. Septoria apii Chest. (68)

On Apium graveolens L. (cult. celery) (15). Marion: Archer 1927 (Survey 1481)

Septoria aquilina Pass. — Cylindrosporium aquilina

721. Septoria argyraea Sacc. (103)

On Elaeagnus angustifolia L. (cult. Russian olive) (10, 15, 199, 502).

Ames: Halsted 1887 (?) (Ell. & Ev. N. Amer. Fung. 2nd Ser. 1967). Shenandoah: Muncie & Archer 1926 (Survey 1670)

Exsic. cited: Thüm. Myc. univ. 2297.

722. Septoria asclepiadicola E. & E. (137)
On Asclepias incarnata L. Manchester: Ball 1897**.

723. Septoria atropurpurea Pk. (395) On Aster cordifolius L. (522) On Aster novae-angliae L. (199, 502)

Septoria aucupariae Bres. - Mycosphaerella aucupariae

Septoria aurea E. & E. - Mycosphaerella aurea

724. Septoria bataticola Taub. (486)

On Ipomoca batatas Lam. (sweet potato) (10, 15, 208). Muscatine Co.: Layton 1927 (Survey 1504)

Septoria besseyi Pk. - Cylindrosporium fraxini

725. Septoria betulina Pass. (88)

On Betula sp. (cult. birch) (15). Shenandoah: Bliss (Survey 1316, 1529)

726. Septoria bromi Sacc. (512) On Bromus secalinus L. (389)

727. Septoria brunellae Ell. & Holw. (154)

On Prunella vulgaris L. (154, 305, 502). Decorah: Holway 1884 (Ell. & Ev. N. Amer. Fung. 1606) (type); Holway 1886. Winterset: Pammel 1927 (Survey 816)

Exsic. cited: Allescher & Schnabl F. bav. 580.

728. Septoria cacaliae E. & K. (305)

On Cacalia atriplicifolia L. (199, 502). Griswold: Dietz 1927 (Survey 795)

On Cacalia reformis Muhl. (522).

Exsic, cited: Ell, & Ev. N. Amer. Fung. 1610.

729. Septoria campanulae (Lev.) Sacc. (305)

On Campanula americana L. (199, 502, 522). Decorah: Holway 1884 (Rabenh. Wint. Fungi eur. 3490); 1888**. Menlo: Archer (Survey 1138)

Septoria cannabina West. = Septoria cannabis (Lasch.) Sacc.

730. Septoria cannabis (Lasch.) Sacc. (5, 305, 346)

Syn. Ascochyta cannabis Lasch., Septoria cannabina West., Psilosphaeria cannabis Rab., Septoria cannabina Peek.

On Cannabis sativa L. (10, 15, 199, 502, 522). Boone: Archer (Survey 1192). Decorah: Holway 1884**. Mondamin: Archer (Survey 1277)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1144; Thüm. Myc. univ. 397; Bri. & Cav. F. para. 94; Ell. & Ev. Fung. Col. 1154; Seymour & Earle Ec. Fung. 388.

Septoria cannabina Peek was reduced to synonomy under Septoria cannabis (Lasch.) Sace. by Martin (305), but Peck's species is retained still in the literature (Allescher (5); Saccardo (428), Oudemans (v. 2, p. 945)).

The distinction between the two species is maintained on difference in spore length; i. e. $45-55\mu$ in S. cannabis and $20-30\mu$ in S. cannabina. Briosi & Cavara, in descriptive material issued with the exsiccati S. cannabis (No. 94) cite the spores as $20-32 \times 1-1.5\mu$. In Iowa collections the spores measure $20-55 \times 1-2\mu$.

It would, therefore, appear that the two species are the same and for this reason the original synonomy proposed by Martin (305) is again

adopted.

731. Septoria celti-gallae Ger. (305)

On Celtis occidentalis L. (199, 502)

Septoria cerasina Peek, collected by Hume and cited under this name by Uppal (502) has been found to be an immature Phyllosticta prunicola. See also Septoria pruni.

732. Septoria chrysanthemella Cav.

On Chrysanthemum sp. (Mrs. C. L. Bell. var. cult.) (15). Shenan-doah: Bliss (Survey 1682)

On Chrysanthemum sp. (Little Bob var. cult.) (15). Shenandoah: Bliss (Survey 1681)

On Chrysanthemum maximum Ram. (Shasta daisy var. cult.) (15, 502). Shenandoah: Bliss (Survey 1683)

In Survey 1681 and 1682 the spores measure 50-80 x 3μ , while in 1683 they are $13-35 \times 1.5-2\mu$.

733. Septoria cirsii Niessl. (5, 103, 139)

Syn. Septoria commonsii E. & E.

On Cirsium altissimum (L.) Spreng. (199, 502)

On Cirsium discolor Muhl. Menlo: Archer 1927 (Survey 1134) On Cirsium iowense (Pammel) Fernald. Shenandoah: Bliss

1927 (Survey 1703)

Exsic. eited: Ell. & Ev. N. Amer. Fung. 1729, 2644; Ell. & Ev. Fung. Col. 673; Krieger, F. sax. 1366.

An examination of the exsiccati shows that there is no difference between the two species, S. commonsii and S. cirsii.

734. Septoria clematidis Rob. & Desm. (5, 134)

Syn. Cylindrosporium clematidis E. & E.

On Clematis pitcheri T. & G. Ames: King 1912. Conesville: Layton 1928.

On Clematis virginiana L. Ledges—Boone: Archer 1927 (Survey 646). Steamboat Rock: Anderson 1913.

Exsic. cited: Allescher & Schnahl, F. bav. 473; Carava, F.

Longobardiae 99; Barth. Fung. Col. 2515.

The synonomy appearing above is based on an examination and comparison of the exsiceati and specimens listed. Undoubtedly, the study of additional exsiceati will result in further synonomy among the species of Phleospora, Septoria, Cylindrosporium, Phyllosticta, etc., which are reported on Clematis. Septoria jackmani E. & E. seems to be distinct.

Septoria compta Sacc. — Mycosphaerella lethalis

735. Septoria conspicua E. & M. (305) On Steironema ciliatum (L.) Raf. (502)

On Steironema quadriflorum (Sims) Hitche. Ames: Carver 1892. Exsic. cited: Ell. & Ev. N. Amer. Fung. 1736; Ell. & Ev. Fung. Col. 75. 736. Septoria convolvuli Desm. (139)

On Convolvulus arvense L. Glenwood: Archer 1927 (Survey 860)

On Convolvulus sepium L. (139, 502). Ames: Hume 1899. West Union: Archer & Layton 1927 (Survey 763)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 3458.

737. Septoria cornicola Desm. (305)

On Cornus spp. (15)

On Cornus alba var. siberica Cy. (cult. tartarian dogwood) (502). Shenandoah: Melhus 1923; Muncie 1927 (Survey 799)

On Cornus alternifolia L. f. (522)

On Cornus amomum Mill. (cult). Shenandoah: Bliss 1927 (Survey 1671)

On Cornus asperfolia Michx. (199)

On Cornus paniculata L'Her. (cult.) (15, 199). Shenandoah: Muncie & Archer 1926 (Survey 1674)

On Cornus stolonifera Michx. (cult.) (15). Shenandoah: Bliss 1927 (Survey 1672)

On Cornus stolonifera var. aurea (cult.) Hort. Shenandoah: Muncie 1925.

On Cornus stolonifera var. lutea (cult.) Hort. Shenandoah: Muncie & Archer 1926 (Survey 1673)

738. Septoria corylina Pk. (305) On Corylus rostrata Ait. (199)

739. Septoria cryptotaeniae Ell. & Rau. (305)

On Asclepias incarnata L. (522)

On Asclepias syriaca L. (522)

On Cryptotaenia canadensis (L.) DC. (502, 522). Ames: Hill 1907. Exsic. cited: Ell. & Ev. Fung. Col. 143; Ell. & Ev. N. Amer Fung. 2638.

740. Septoria dianthi Desm. On Dianthus sp. (502)

741. Septoria diervillae Pk. (125)

Syn. Septoria diervillae E. & E., Septoria diervillicola E. & E.

On Diervilla lonicera Mill. (Diervilla trifida Moench.) (522).

Steamboat Rock: Anderson 1913.

Exsic. cited: Barth. Fung. Col. 2479.

On the Iowa collection the pycnidia are amphigenous on spots which may be definitely limited or which may be irregular and extensive with no definite margin. This is true likewise of the example seen of *S. diervillicola* E. & E. (sub. *S. diervillae* E. & E.) in Barth. Fung. Col. 2479. Peck (298, p. 98) describes the pycnidia as epiphyllous in *S. diervillae*, while Ellis & Everhart (125, p. 44) describe them as hypophyllous. The two species are certainly not distinct. Cfr. Saccardo (428, v. 10, p. 356). 742. Septoria divaricatae E. & E. (139)

On Phlox divaricata L. (139, 305). Nevada: Melhus 1924.

On Phlox divaricata L. var. laphamii Wood (502). Decorah: Holway 1883.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 3175.

743. Septoria elymi E. & E. (141)

On Elymus robustus Scribn. & Sm. Rockwell City: Archer & Layton 1927 (Survey 690).

Exsic. cited: Ell. & Ev. N. Amer. Fung. 2854.

744. Septoria equiseti Desm. (305) On Equisetum sp. (100, 305, 502)

745. Septoria erigerontis Peck var. boltoniae Webber (85)

On Boltonia asteroides L'Her. Galt: Archer 1927 (Survey 1224) The Iowa collection was checked with type material at Wisconsin by

J. J. Davis.

746. Septoria erigerontis Peck (305)

Syn. Septoria erigerontis Peck, Septoria erigerontea (Peck) Sacc., Septoria erigerontis B. & C., Septoria erigerontis Pk. var. effusa Davis.

On Erigeron annuus (L.) Pers. (522)

On Erigeron canadense L. Ledges—Boone: Archer 1927 (Survey 647)

On Erigeron philadelphicus L. Ruthven: Archer & Layton 1927 (Survey 721)

On Erigeron ramosus (Walt.) BSP. (199, 502, 522)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1129, 2657; Ell. & Ev. Fung. Col. 1680; Barth. Fung. Col. 3384; Seym. & Earle, Ec. Fungi 311.

In Survey 721 the pyenidia have the effuse appearance noted by Davis (90, p. 679); while in Survey 647 the spots have arid centers and are definitely limited by brownish borders. An examination of the example of Ell. & Ev. N. Amer. Fung. 1129 shows that both kinds of spots may exist on the same leaf. The difference in appearance is most likely due to physiological relations. The variety named by Davis is, therefore, added to the synonomy.

747. Septoria eupatoriae Rob. & Desm. (305)

On Eupatorium urticaefolium Reichard (199, 502)

Septoria fraxini Desm. — Cylindrosporium fraxini

748. Septoria fumosa Pk. (95, 305)

On Solidago sp. Ames: Carver 1895.

This specimen agreed in macroscopic appearance with S. angularis Dearn. & Barth. (Fung. Col. 4875), but the spores measured 15-60 x 1.5μ . These measurements correspond more nearly with those of Peck.

749. Septoria gaillardiae E. & E. (143)

On Gaillardia sp. (cult.) (15). Shenandoah: Bliss 1927 (Survey 1669)

On Gaillardia sp. (Hort. var. "Grand superba"). Shenandoah: Muncie & Archer 1926 (Survey 1668)

Exsic. cited: Ell. & Ev. Fung. Col. 1450.

750. Septoria helenii E. & E. (305)

On Helenium autumnale L. Maynard: Archer 1927 (Survey 754)

On Helenium hoopesii Gray (cult. orange sneezeweed) (15). Shenandoah: Muncie & Archer 1926 (Survey 1667)

In the Iowa material the spores are mostly straight, 13-40 x 2μ.

751. Septoria helianthi E. & K. (271)

On Helianthus grosse-serratus Martens, Pocahontas: Archer 1927 (Survey 1347)

On Helianthus strumosus L. (143)

On Helianthus tuberosus L. (502). Ledges—Boone: Coe 1912. Exsic cited: Ell. & Ev. Fung. Col. 2582, 3079.

Septoria irregularis Pk. - Cylindrosporium toxicodendri

752. Septoria lactucicola Ell. & Mart. (305)

On Lactuca canadensis L. (502, 522). Ames: Hume 1899; King 1910; Rolfs 1891. Ledges-Boone: Coe 1912. Menlo: Archer 1927 (Survey 1139) **

On Lactuca hirsuta Muhl. (522)

On Lactuca scariola L. (502). Ledges-Boone: Coe 1912.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1613; Ell. & Ev. Fung. Col. 285.

753. Septoria leptostachyae E. & K. (305)

On Phryma leptostachya L. (199, 502, 522)

754. Septoria liatridis Ell. & Davis (271)

On Liatris sp. (8). Decatur Co.: Anderson 1901. Exsic. cited: Davis F. Wis. 54.

755. Septoria lobeliae Peck (305)

On Lobelia spicata Lam. (305). Grundy Center: Archer 1927 (Survey 790)

On Lobelia siphilitica L. (199, 305, 502). Decorah: Holway 1884. Exsic. cited: Ell. & Ev. N. Amer. Fung. 1732; Ell. & Ev. Fung. Col. 282b.

Septoria lupulina Ell. & Kell. (502) = Cylindrosporium humuli

756. Septoria lycopersici Speg. (275)

On Lycopersicon esculentum Mill. (cult. tomato) (15, 191, 376, 502). Ames: Buchanan 1908; King 1915. Clarinda: Van Sant 1905. Sac City: Lee 1908. Waterloo: Woods 1911.

757. Septoria macropodia Pass. (512)

Syn, Septoria graminum Desm, forma sclerochloa durae Thüm., Septoria poae-trivialis Cocc., Septoria annua E. & E., Septoria poae-annuae Bres.

On Poa pratensis L. (bluegrass) (15). Sac City: Archer 1927

(Survey 711)

Exsic. cited: Thum. Myc. univ. 593; Ell. & Ev. Fung. Col. 1448;

Krieger, F. sax. 1645.

According to the work of Weber (512) the Septoria occurring on Poa pratensis is distinct from the species found on various other cereals and grasses. Weber found that his specimen was distinct from the type collection of Septoria graminum Desm.

The present authors in their studies of the exsiccati cited conclude that the various species reported on Poa are the same. The spore measurements and shape correspond to the descriptions and figure given by Weber. For that reason, the synonomy given above is suggested.

758. Septoria malvicola E. &. M. (305)

On Malva rotundifolia L. (502, 522). Nora Springs: Archer 1927 (Survey 763). Pocahontas: Archer 1927 (Survey 1348)

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1727; Ell. & Ev. Fung. Col. 146; Barth. Fung. Col. 2174, 3684; Seymour & Earle Ec. Fung. 268a.

Septoria meliloti Sacc. - Mycosphaerella lethalis

759. Septoria microsperma Pk. (305)

On Betula sp. (199, 502)

760. Septoria mimuli E. & K. (305) On Mimulus ringens L. (199, 502)

761. Septoria nabali B. & C. (305)

Syn. Septoria prenanthis E. & E. On Prenanthes alba L. (522)

On Prenanthes racemosa Michx. (199, 502)

Septoria negundinis E. & E. — Septoria aceris

762. Septoria nodorum Berk. (511) On Triticum vulgare Vill. (502)

763. Septoria nolitangeris Ger. (305)

On Impatiens pallida Nutt. (8, 502). Decatur Co.: Anderson 1904. Decorah: Holway 1883, 1886 (Rabenhorst-Winter, F. eur. 3495) Exsic. cited: Ell. & Ev. N. Amer. Fung. 2949.

Septoria oculata Ell. & Kell. (522) = Cercospora oculata Ell. & Kell.

764. Septoria oenotherae West. (305)

On Oenothera biennis L. (199, 502, 522). Conceville: Archer 1927 (Survey 955). Decorah: Holway 1884; 1888**. Menlo: Archer 1927 (Survey 1129)

On Oenothera lamarkiana Ser. (cult. lamark evening primrose) (15). Shenandoah: Bliss 1927 (Survey 1666)

765. Septoria ostryae Pk. (305)

On Ostrya virginiana (Mill.) K. Koch. (502). Ames: Hume 1899. Exsic, cited: Barth. Fung. Col. 3485.

766. Septoria pachyspora Ell. & Holw. (154)

On Zanthoxylum americanum Mill. (154, 305, 502). Decorah: Holway 1884 (type) (Ell. & Ev. N. Amer. Fung. 1615)

Exsic. cited: Barth, Fung. Col. 2080.

767. Septoria parietariae Davis (86)

On Parietaria pennsylvanica Muhl. (502, 522). Glenwood: Archer 1927 (Survey 868)

The spores measured 20-51 x 1-1.5 μ .

768. Septoria passerinii Sacc. (512)

On Hordeum jubatum L. (502). Conesville: Archer 1927 (Survey 949). Rippey: Archer 1927 (Survey 828)

On Hordeum vulgare L. Waukon: Pammel 1908.

769. Septoria phlogis Sacc. & Speg. (139, 305)

On Phlox sp. (cult.) Shenandoah: Bliss (Survey 1664)

On Phlox paniculata L. (Hort. var. La Vague) (15, 305). Shenan-doah: Muncie & Archer (Survey 1665)

Exsic. cited: Krieger F. sax. 1591; Allescher & Schnabl. F. bav. 675; Seym. & Earle Ec. Fungi 491.

The spores were straight to irregularly flexuous, $50\text{-}60 \times 1\text{-}1.5\mu$, which distinguishes this species from Septoria divaricatae E. & E.

This fungus was reported by Anderson, Haskel et al. (15) as Leptosphaeria phlogis Oud. However, it seems that the connection with Leptosphaeria is purely observational. See Ritzema Bos (421a).

770. Septoria pileae Thüm. (305)

On Pilea pumila (L.) Gray (199, 502)

771. Septoria piricola Desm. (428, v. 3, p. 487) On Pyrus communis L. (cult. pear) (8)

On Pyrus malus L. (502)

772. Septoria pisi West (71, 103)

On Pisum sativum L. Spencer: Archer 1927 (Survey 1147)

Exsic. eited: Ell. & Ev. N. Amer. Fung. 2649, 2946; Ell. & Ev. Fung. Col. 437; Barth. Fung. Col. 4077.

773. Septoria platanifolia Cke. (305)

On Platanus occidentalis L. (199, 502)

774. Septoria podophyllina Pk. (305)

On Podophyllum peltatum L. (502, 522). Cedar Rapids: Archer 1927 (Survey 605). Decorah: Holway 1885. Ledges—Boone: Coe 1912. St. Olaf: Pammel 1924.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1138; Barth. Fung. Col. 4177; Rabenhorst-Winter F. eur. 3496; Kellerman, Ohio Fungi 15.

775. Septoria polygonorum Desm. (305)

On Polygonum lapathifolium L. (8)

On Polygonum pennsylvanicum L. (8, 502). Ames: Stewart 1894; Pammel 1908. Ledges—Boone: Coe 1912. Shenandoah: Gilman & Bliss 1927 (Survey 924)

On Polygonum persicaria L. (502). Ledges-Boone: Coe 1912.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 531; Barth. Fung. Col. 2583, 3278.

776. Septoria populi Desm. (428, v. 3, p. 502)

On Populus sp. (cult. poplar) (15). Shenandoah: Bliss 1927 (Survey 1663)

Septoria prenanthis E. & E. = Septoria nabali B. & C.

777. Septoria pruni Ellis (305)

On Prunus americana Marsh. Ames: Hume 1899.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1151; Kellerman Flora Kentucky 85; Kellerman Flora Kansas 627; Rabenhorst-Winter-Pazschke, F. eur. 3886.

The Iowa collection cited above was listed by Uppal (502) as *S. cerasina* Pk. No spores are present, but in comparison with the exsiceati cited the specimen resembles microscopically *Septoria pruni* Ellis.

778. Septoria pyri Cast. (305)

On Pyrus coronaria L. (199, 502)

On Pyrus malus L. (199, 502)

779. Septoria querceti Thüm. (305) On Quercus sp. (199, 502)

On Quercus rubra L. (199)

780. Septoria rhaponticae Thüm. (428, v. 3, p. 555) On Rheum rhaponticum L. (199, 502)

Septoria rhoina (B. & C.) Sacc. — Cylindrosporium toxicodendri Septoria ribis Desm. — Mycosphaerella grossulariae Septoria rubi West. = Mycosphaerella rubi

781. Septoria rudbeckiae Ell. & Halst. (153) On Rudbeckia laciniata L. (199, 502)

On Rudbeckia triloba L. (199, 502)

782. Septoria salliae Gerard (305) On Acer saccharinum L. (199)

783. Septoria sambucina Peck (305)

On Sambucus canadensis L. Ames: Pammel 1914. Osage: Archer 1927 (Survey 1403). Sioux Rapids: Archer 1927 (Survey 1360). On Sambucus racemosa L. (199, 502)

Exsic. eited: Ell. & Ev. N. Amer. Fung. 3370; Ell. & Ev. Fung. Col. 846; Barth. Fung. Col. 2585, 4485.

Septoria saccharina E. & E. - Septoria aceris

784. Septoria saniculae E. & E. (137)

On Sanicula marilandica L. (8, 522, 530). Decatur Co.: Anderson 1905.

The specimen cited above is immature and does not have spores, but otherwise there is agreement in the macroscopic characters with the original description. (Ellis and Everhart (137)).

785. Septoria scrophulariae Pk. (275, 305)

On Scrophularia leporella Bicknell. Forest City: Lundberg 1927.

Menlo: Archer 1927 (Survey 1135)

On Scrophularia marilandica L. (8, 502, 522, 530). Ames: Carver 1892; Hill 1907; King 1910. Ledges—Boone: Coe 1912. Fayette: Wilson 1909 (Wilson & Seaver Ascom. & Low. Fung. 70)

Exsic. eited: Ell. & Ev. Fung. Col. 581; Barth. Fung. Col. 2279, 2876; Ell. & Ev. N. Amer. Fung. 2656; Kellerman Ohio F. 138; Rabenhorst-Winter, F. eur. 2993.

786. Septoria scutellariae Thüm. (103)

On Scutellaria lateriflora L. (522)

On Scutellaria versicolor L. Goldfield: Archer 1927 (Survey 1234) Exsic. cited: Ell. & Ev. N. Amer. Fung. 3556.

787. Septoria secalis Prill. & Del. (512)

On Secale cereale L. (cult. rye). Pottawattamie Co.: Archer 1927 (Survey 551)

788. Septoria sedi West. (90)

On Sedum spectabile Boreau (cult. showy stonecrop) (15). Shenan-doah: Muncie & Archer 1926 (Survey 1677)

On Sedum spectabile Boreau var. brilliant (15). Shenandoah: Bliss 1927 (Survey 1675)

On Sedum spectabile Boreau Hort. var. variegata (15). Shenandoah: Bliss 1927 (Survey 1676)

Exsic. cited: Barth. Fung. Col. 3081.

Judging from Peck's description, Septoria sedicola Pk. is not different from Septoria sedi West.

789. Septoria sicyi Pk. (305)

On Echinocystis lobata (Michx.) T. & G. (199, 502)

790. Septoria sigmoidea E. & E. (147) On Panicum virgatum L. (162) 791. Septoria silenes West. (305)

On Silene antirrhina L. (502). Ontario: Faurot & Paddock 1901. On Silene stellata (L.) Ait. fil. (8, 502, 522). Decatur Co.: Anderson 1903. Ledges—Boone: Anderson 1913.

Exsic. cited: Ell. & Ev. Fung. Col. 439; Barth. Fung. Col. 3484, 4178; Ell. & Ev. N. Amer. Fung. 1141, 2857.

The Iowa collection on Silene antirrhina agrees in host and fungus with the specimen in Fung. Col. 4178. The latter specimen, however, was issued under the name S. silenicola (E. & M.) Sacc. Under this name, Martin (305, p. 74) cites N. Amer. Fung. 1141 (on Silene stellata) as representative of the species, but this specimen does not agree at all with the description for S. silenicola. In fact, it seems to fit more nearly, with its large confluent spots, under the original description of Septoria silenes West.

An examination of the Iowa collections shows that these pallid, borderless spots may occur singly or that they may become confluent; depending

presumably upon the nature of the developmental conditions.

Further in the exsiceati, Fung. Col. 439 was issued as Septoria silenicola on Silene noctiflora. However, this specimen is not distinguishable from the specimens on Silene noctiflora in Fung. Col. 3484, and N. Amer. Fung. 2857, which were issued as Septoria noctiflorae. All three have pallid spots with more or less well defined borders. In fact, some of the leaves in N. Amer. Fung. 439 have spots with no border and in Fung. Col. 3484 it is seen that when several spots become confluent the colored border is no longer visible.

In view of such lack of distinction, it is quite likely that future work will prove these names to be mere synonyms of Septoria silenes West.

792. Septoria silphii E. & E. (305) On Silphium perifoliatum L. (305)

793. Septoria sisymbrii Ell. (305) On Dentaria laciniata Muhl. (8)

Septoria smilacina Dur. & Mont. (502) upon reexamination was found to be Sphaeropsis cruenta.

794. Septoria smilacinae E. & M. (305)

On Smilacina racemosa (L.) Desf. (502, 522)

On Smilacina stellata (L.) Desf. (199)

795. Septoria solidaginis Thüm. (305) On Solidago canadensis L. (199, 502)

796. Septoria speculariae B. & C. (305)

On Specularia perfoliata L. (199, 502). Ames: Melhus 1924. Conesville: Archer 1927 (Survey 942). Nevada: Melhus 1924.

Exsic. cited: Kellerman & Swingle, Kansas Fungi 22a, 22b; Ell. & Ev. Fung. Col. 1682; N. Amer. Fung. 1971; Rabenhorst-Winter, F. eur. 3699; Rayenel, F. Amer. 262.

Septoria sorbi Lasch. - Mycosphaerella aucupariae

797. Septoria sphaerelloides E. & K. (305) On Hupericum mutilum L. (199, 502)

798. Septoria stachydis Rob. and Desm. (103)

On Stachys tenuifolia Willd. (502). Ames: Carver 1892. Exsic. cited: Krieger Fungi sax. 1393, 1394; Allesch, & Schn. Fung. Bav. 374; Rabenh. Pazsch. Fung. eur. 4185; Barth. Fung. Col. 4179.

799. Septoria symphoricarpi E. & E. (132, 305)

On Symphoricarpos occidentalis Hook. (502). Forest City: Bakke 1908.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 1731; Ell. & Ev. Fung. Col. 972; Barth. Fung. Col. 4388.

Septoria toxicodendri Curt. = Cylindrosporium toxicodendri

800. Septoria tritici Desm. (511)

On *Triticum vulgare* Vill. (cult. wheat) (15, 191, 406, 502). *Ames:* King 1909.

Septoria ulmi Fr. = Mycosphaerella ulmi 801, Septoria urticae Desm. & Rob. (103)

On Laportea canadensis (L.) Gaud. (199, 522)

On Urtica gracilis Ait. (502). Ledges—Boone: Coe 1912. Menlo: Archer 1927 (Survey 1127). Sioux Rapids: Archer 1927 (Survey 1362)

Exsic. cited: Allescher & Schnabl. F. bav. 185; Sydow. Myc. mar. 395; Krieger, F. sax. 1648, 1697; Thüm. Myc. univ. 500.

802. Septoria verbenae Rob. & Desm. (305)

On Verbena hastata L. (502). Ledges—Boone: Coe 1912.

On Verbena urticaefolia L. (199). Ledges-Boone: Coe 1912.

Exsic. cited: Barth. Fung. Col. 2082, 2083, 3877; Seymour & Earle, Ec. Fung. 345; Thüm. Myc. univ. 1293.

803. Septoria veronicae Desm. (428, v. 3, p. 534)

On Veronica virginica L. (199, 502)

804. Septoria virgaureae Desm. (305)

On Solidago canadensis L. Des Moines: Archer 1927 (Survey 1065). Ft. Dodge: Archer 1927 (Survey 686)

On Solidago serotina Ait. (199, 502). Greenfield: Archer 1927 (Survey 1112)

On Solidago speciosa Nutt. Ames: Carver 1892.

Exsic. cited: Krieger, F. sax. 685; Ell. & Ev. N. Amer. Fung. 1155,

2641: Ell. & Ev. Fung. Col. 847, 1877.

Septoria francisci Sace. (S. dolichospora E. & E.) in N. Amer. Fung. 2641 and Fung. Col. 847, macroscopically, were similar to S. virgaureae in Krieger, F. sax. 685. Also Septoria solidaginis Peck in N. Amer. Fung. 1155 and Fung. Col. 1877 appeared to be much the same as the preceding three, except that the spots were much smaller. In the four American species the spores measured $20\text{-}90 \times 1.5\mu$. The Krieger specimen and the Iowa collection agreed in macroscopic appearance and in all the spores measured $23\text{-}130 \times 1.5\mu$.

805. Septoria viridi-tingens Curt. (305)

On Allium tricoccum Ait. (8, 502). Decatur Co.: Anderson 1903. Decorah: Holway 1883.

This specimen was reported by Uppal (502) as Septoria alliorum West. on Allium porrum.

Exsic. cited: Underwood & Cooke, Illust. fungi 74; Ell. & Ev. N. Amer. Fung. 1612; Ell. & Ev. Fung. Col. 76.

806. Soft-scald (407)

On Pyrus malus L. (cult. apple) (407)

Sorosporium bullatum Schröt. = Tolyposporium bullatum Sorosporium cenchri P. Henn. = Sorosporium syntherismae

807. Sorosporium provinciale (Ell. & Gall.) Clint. (74, p. 39) On Andropogon furcatus Muhl. Amana: Melhus 1924.

808. Sorosporium reilianum (Kühn.) McAlp.

Syn. Sphacelotheca reiliana (Kühn.) Clint.

On Holcus sorghum L. (Sorghum vulgare Pers.) (72, 74, 245, 383, 389). Ames: R. H. Porter 1912. Frankville: Holway 1895. On Zea mays L. (8)

Sorosporium sorghi Link. - Sphacelotheca sorghi

809. Sorosporium syntherismae (Pk.) Farl. (74, p. 38)

On Cenchrus carolinianus Walt. (16, 72, 245, 368, 369, 522). Ames: Anderson 1913; Combs 1894. Conesville: Gilman 1927 (Survey 1312)**. Iowa City: Hitchcock 1889**. Quarry: Pammel 1902. Turin: Pammel 1894.

On Digitaria sanguinalis (L.) Scop. (368, 383)

On Panicum capillare L. (72, 368, 380). Ames: Combs 1894; Howe -; Hume 1898, 1899; Wright 1892. Turin: Pammel 1894.

On Panicum dichotomiflorum Michx. (Panicum proliferum) (72, 74, Ames: Pammel 1922. Chariton: Pammel 1922. Des Moines: Woodruff 1902. Oelwein: Archer 1927 (Survey 1438)**.

This fungus has been reported erroneously from Iowa on Cenchrus tribuloides. Investigation of the distribution of this host indicates that the proper name for this plant in Iowa is C. carolinianus.

810. Sphaceloma symphoricarpi Barrus and Horst. (47)

On Symphoricarpos albus (L.) Blake var. laevigatus (Fernald) Blake (Symphoricarpos racemosus Michx.) (cult. snowberry) (47). Ames: Haskell 1927**: Summers 1928.

811. Sphacelotheca hydropiperis (Schum.) DeBy. (74, p. 30) On *Polygonum sagittatum* L. (16, 72, 74)

Sphacelotheca reiliana (Kühn.) Clint. = Sorosporium reilianum 812. Sphacelotheca sorghi (Lk.) Clinton (74, p. 25)

On Holcus sorghum L. (72, 74, 245, 383, 389). Ames: Blake 1899; Gilman 1924. Shenandoah: Anderson 1913.

On Holcus sudanensis Bailey (cult. sudan grass). Griswold: Leach & Dietz 1927 (Survey 1599)

813. Sphaerella filicum Desm. (428, v. 1, p. 532)

On Adiantum pedatum L. Ames: Carver 1892.

Sphaerella impatientis Pk. & Clint. = Mycosphaerella impatientis Sphaeronema fimbriatum E. & H. = Ceratostomella fimbriata

814. Sphaeropsis sp.

On Caragana arborescens Lam. (cult. Siberian pea tree) (15). Ames: Muncie 1927 (Survey 1688)

815. Sphaeropsis albescens E. & E. (141)

On Acer negundo L. (15). Ames: Summers 1927 (Survey 1702). Decorah: Holway 1892.

Exsic. cited: Ell. & Ev. N. Amer. Fung. 2772, 2942; Ell. & Ev. Fung. Col. 671.

^{&#}x27;Fide-G. P. Clinton.

816. Sphaeropsis cruenta (Fr.) comb. nov.

Syn. Diplodia smilacina Berk., Phyllosticta convallarie Pers., Sphaeria lichenoides convallariaecola DC., Sphaeria cruenta Fres., Depazea cruenta Chev., Sphaeria convallariaecola Duby, Phyllosticta cruenta Kiekx., Phyllosticta pallidior Peek, Macrophoma cruenta Ferr.)—Seaver (446, p. 11). Halposporella smilacis (E. & E.) Petr. & Syd., Sphaeropsis smilacis E. & E., Sphaeropsis smilacis var. latispora Peek, Sphaeropsis latispora (Dearn.)—Petrak & Sydow (404, p. 89). Dothiorella smilacina (Pk.) Petr. & Syd., Sphaeropsis smilacina Peek, Phoma smilacina Saec., Macrophoma smilacina Berl. & Vogl., Phyllosticta smilacina Dearn., Phyllosticta smilacis E. & E., Macrophoma smilacis (Bub.) Petrak & Sydow (404, p. 250). Phyllostictina cruenta (Fr.) Petr. & Syd. Ascospora cruenta Lamb., Macrophoma polygonati (Ferr.)—Petrak & Sydow (404, p. 209-210)

On Polygonatum commutatum (R. & S.) Dietr. Ames: King 1910. Humboldt: Archer 1927 (Survey 1216). Steam-

boat Rock: Anderson 1913.

On Smilacina racemosa (L.) Desf. (446). Decorah: Holway 1885. Ledges-Boone: Anderson 1913.

On Smilax herbacea L. Ames: Combs 1894.

On Smilax hispida Muhl. Indianola: Archer 1927 (Survey 1082).

On Smilax rotundifolia L. Ames: Anderson1913.

Exsic. cited: Phyllosticta cruenta (Fr.) Kickx.—Archer, W. Va. Survey 3175 (U. S. D. A. Herb.); Thüm. Myc. univ. 1189; Cavara F. longobardiae 90; Rabenhorst- Winter, F. eur. 3695; Linhart, F. hung. 98; Ell. & Ev. N. Amer. Fung. 752; Ell. & Ev. Fung. Col. 443, 1136; Barth. Fung. Col. 4652; Underwood & Cooke Ill. fungi 76. Phyllosticta smilacis E. & M.—Ell. & Ev. N. Amer. Fung. 3252; Ell. & Ev. Fung. Col. 663; Barth. Fung. Col. 2547, 2851, 2952, 4247, 5041; Wilson & Seaver, Ascom. & Low. Fung. 43. Phyllostictina cruenta (Fr.) Petr. & Syd.-Petrak Myc. carp. 419. Sphaeropsis smilacis E. & E.-Wilson & Seaver, Ascom. & Low. Fung. 49.

The species, Dothiorella smilacina (Pk.) Petrak & Sydow; Haplosporclla smilacis (E. & E.) Petr. & Syd.; Phyllostictina subeffusa (E. & E.) Petr. & Syd.; Phyllostictina cruenta (Fr.) Petr. & Syd.; Phyllostictina pallidor (Pk.) Petr. & Syd., are untenable. The forms which Petrak & Sydow (404) describe under these several species are nothing more than developmental stages of a single fungus. These two authors seek to retain the old genera Dothiorella, Haplosporella, and Botryodiplodia but these have been proven to be mere growth forms (Archer 14, p. 31-45, p. 78) of

Sphaeropsis.

The gelatinous condition of the spores in the genus Haplosporella (Petr. & Sydow 404, p. 16) is not a reliable character for marking a genus. This gelatinous substance is to be found constantly within the younger stages of the pycnidia of various species of Sphaeropsis (Archer 14, p. 40;

pl. 5, fig. 1).

Petrak and Sydow (404) make use of the term stroma in their characterization of genera. However, this is another unreliable character since

the real nature of this substance has been fully explained (Archer 14, p.

73-77).

Throughout the work of Petrak and Sydow (404) there is constant reference to "Kümmerformen". This term has been applied freely to such examples that did not adhere to the preconception of the particular species or genus in hand. If due and proper consideration were given these "Kümmerformen" then the distinction between a large number of the species and genera, held distinct by Petrak and Sydow, will become invalid.

A careful examination of the exsiccati cited above has shown beyond doubt that the specimens were immature stages of Sphaeropsis! In all, the spores have a distinct epispore, and the cell contents are granular, both

signifying immaturity!

Furthermore, a careful search reveals transition stages in many of the specimens; 1-celled hyaline spores with granular contents (Macrophoma or Dothiorella), 1-celled brown spores with granular or homogeneous content (Sphaeropsis or Haplosporella), and 2-celled brown spores with homogeneous content (Diplodia or Botryodiplodia). Often a hyaline, 2-celled spore was found. (Cfr. Bubak, 62, p. 20-21.)

This was particularly true of Survey 1082; Survey 1216; Ames: King 1910; Ames: Anderson 1913; Steamboat Rock: Anderson 1913. Also in Fung. Col. 433; Linhart, F. hung. 98 (two examples); Cavara, F. longbard.

90; N. Amer. Fung. 2352; and Fung. Col. 2952.

The example of *Sphaeropsis smilacis* E. & E. (Wilson & Seaver Asco. & Lower fungi 49) on stems agrees well in all points with the other specimens which occur on leaves. In this Sphaeropsis specimen only comparatively few of the spores were brown, still fewer were 1-septate, the majority were hyaline, with granular contents, thereby resembling the spores which are produced in the leaf spots. Dearness (96, p. 354) considers *S. smilacis* E. & E. to be a Melanconium. However, he gives no reasons for this decision. As already stated above, the example of this fungus in Wilson & Seaver was found to be a true Sphaeropsis.

In culture *Phyllosticta cruenta* from *Smilax hispida* had the exact character of Sphaeropsis (Cfr. Archer 14, p. 73-77). Some of the spores were hyaline and 1-celled but most were 1 or 2-celled and brownish in color.

From these observations it has been considered best to combine under one name, *Sphaeropsis cruenta*, all the forms occuring on Smilax, Smilacina and Polygonatum, thus following the example of Dearness (96, p. 351-352) and Seaver (446, p. 11). *Diplodia smilacina* Berk. (Saccardo 428, v. 3, p. 370) is added also.

Sphaeropsis malorum Pk. — Physalospora malorum.

817. Sphaeropsis ulmicola Ell. & Ev. (140)

On Ulmus americana L. Grinnell: Muncie 1923. Sphaerotheca castagnei Lev. — Sphaerotheca humuli.

818. Sphaerotheca humuli (DC.) Burr. (431)

On Agrimonia sp. Ames: Bessey 1878.

On Agrimonia gryposepala Wallr. (7, 171, 522). Decatur Co.: Anderson 1904.

On Bidens sp. (7). Ames: Carver 1892.

On Bidens cernua L. (199).

On Bidens connata Muhl. (199).

On Bidens frondosa L. (7, 8, 218, 522.) Ames: Bessey 1877; Brown 1890; Carver 1892; Combs 1894; Hume 1899. Boone: Archer 1927 (Survey 1194)**. Decatur Co.: Anderson 1904. Decorah: Holway 1879**.

On Bidens involucrata (Nutt.) Britt. (7, 8).

On Bidens laevis (L.) BSP. (7, 199). Ames: Combs 1894. Des Moines: Pammel 1894.

On Bidens vulgata Greene. Garner: Archer 1927 (Survey 1369).

On Epilobium coloratum Muhl. (7, 522). Ames: Combs 1894. Fayette: Fink 1894 (Ell. & Ev. N. Amer. Fung. 2nd Ser. 3212)

On Erechtites hieracifolia (L.) Raf. (7, 8, 522). Ames: Bessey 1878.

On Erigeron canadensis L. (7, 522). Ames: Carver 1894; Combs 1894. Mondamin: Archer 1927 (Survey 1295).

On Erigeron philadelphicus L. (199). On Gerardia tenuifolia Vahl. (199).

On Geum canadense Jacq. (199). Ames: Carver 1895.

On Potentilla monspeliensis L. (189).

On Prunella vulgaris L. (7). Ames: Bessey 1882. On Rhus glabra L. (7, 201, 522). Boone: Coe 1912.

On Rhus hirta dissecta Rehd. (cult. cut leaf sumae) (15). On Rosa sp. Marshalltown: Archer 1927 (Survey 1414)**.

On Rosa blanda Ait. Ames: Carver 18921.

On Rosa pratincola Greene (Rosa heliophila Greene) (7, 8). Ames: Crane 1896. West Okoboji: Martin 1925**.

On Sonchus oleraceus L. (7, 171, 522).

On Taraxacum officinale Weber (7, 8, 522). Ames: Combs 1894; Pammel 1910.

On Veronica virginica L. (7, 8, 522). Ames: Bessey 1878; Carver 1892. Decatur Co.: Anderson 1904.

On Viola cornuta L. Primghar: Knox 1911.

On Viola tricolor var. hortensis DC. (cult. pansy) (406).

819. Sphaerotheca lanestris Harkn. (431)

On Quercus alba L. (10, 500).

On Quercus stellata Wang. (Quercus minor Sarg.) (500). Sphaerotheca mali (Duby) Burr. = Podosphaera leucotricha.

820. Sphaerotheca mors-uvae (Schw.) B. & C. (431)

On Ribes sp. (7, 8, 171).

On Ribes sp. (cult. current) (406).

On Ribes sp. (cult. gooseberry) (15,340).

On Ribes cynosbati L. (7, 522). Ames: Bessey 1876. Fayette: Fink 1894.

On Ribes floridum L'Her. (380, 522). Jewell Jet.: Carver 1895. Sioux Rapids: Archer 1927 (Survey 1364).

In the monograph of Salmon (431) Ribes floridum is not reported as a host for this fungus.

On Ribes gracile Michx. (7).

On Ribes grossularia L. (cult. gooseberry) (15, 53, 380). Fayette: Pammel 1914.

On Ribes rotundifolium Michx. (7, 218, 522).

^{&#}x27;Fide-E. S. Salmon.

On Ribes vulgare Lam. (Ribes rubrum L.) (cult. currant) (189). Council Bluffs: Williams 1894.

821. Sphaerotheca pannosa Lev.

On Prunus persica (L.) Stokes (cult. peach) (189).

On Rosa sp. (cult. rose) (7, 15, 363, 383). Ames: King 1910. Lake View: Morenus 1914.

On Rosa blanda Ait. (7, 171, 522).

On Rosa multiflora Thunb. (8, 15, 376). Ames: Anderson 1913. Decatur Co.: Anderson 1904. Lamoni: Anderson 1913.

On Rosa setigera Michx. (15).

The fungus reported by Bessey (53) and Hitchcock (218) as Sphaerotheca pannosa on Ribes grossularia L. and R. rotundifolia Michx. is referred to Sphaerotheca mors-uvae.

822. Sphaerotheca phytoptophila Kellerm. & Sw. (431)

On Celtis occidentalis L. (7, 200). Ames: Carver 1895; Halsted 1889 (Ell. & Ev. N. Amer. Fung. 2nd Ser. 2336).

Sphaerotheca pruinosa C. & P. = Sphaerotheca humuli.

823. Spindle tuber (non-parasitic) (173)

On Solanum tuberosum L. (potato) (15).

824. Spondylocladium atrovirens Harz. (313) On Solanum tuberosum L. (potato) (190).

825. Sporodinia grandis Link (290) On Pleurotus sp. Ames: Hill 1907.

Sporonema phacidioides Desm. = Pyrenopeziza medicaginis.

Sporotrichum graminis Auct. - Sporotrichum poae.

826. Sporotrichum poae Pk. (477)

On Phleum pratense L. (10, 195, 389).

On Poa pratensis L. (406).

Stagonospora apocyni (Pk.) Davis = Cylindrosporium apocyni.

827. Streak (non-parasitic) (181)

On Lycopersicon esculentum Mill. (tomato) (15).

828. Syncephalis cornu van Tieghem (489, 490, 491) On Mucor mucedo L. Ames: Gilman 1927.

Synchytrium aecidioides (Pk.) Wilson = Synchytrium decipiens.

829. Synchytrium anemones (DC.) Wor. (172)

On Anemone cylindrica Gray (410). Ames: Pammel 1909. Kelley:
Morris 1922.

On Anemone quinquefolia L. (Anemone nemorosa) (522). Decorah: Holway 1879; 1883**.

Exsic. cited: Barth. Fung. Col. 4294; Ell. N. Amer. Fung. 203; Krieger, Fung. sax. 391; Thüm. Myc. univ. 129.

830. Synchytrium anomalum Schroet. (172)

On Adoxa moschatellina L. (410). Decorah: Holway 1880 (Ell. & Ev. N. Amer. Fung. 2nd Ser. 2431).

831. Synchytrium decipiens Farl. (169)

Syn. Synchytrium aecidioides (Pk.) Wilson,

On Amphicarpa monoica (L.) Ell. (Falcata comosa) (8, 54, 410, 522, 530). Ames: Thomas 1878. Decatur Co.: Anderson 1897. Decorah: Holway 1882; Melhus 1918. Fayette: Wilson 1909 (Wilson & Seaver Ascom. & Low. Fung. 72). Moingona: Welch 1900. Spirit Lake: Halsted 1885**.

On Amphicarpa pitcheri T. & G. (8, 522). Ames: Pammel 1909¹.

Decatur Co.: Anderson 1905.

832. Synchytrium fulgens Schroet. (169)
On Qenothera hiennis L. (522).

833. Synchytrium holwayi Farl. (169)

On Monarda sp. (410).

On Monarda mollis L. (522) (not M. fistulosa as reported). Decorah: Holway 1883 (Ell. & Ev. N. Amer. Fung. 2nd Ser. 1807); 1888 (Vestergren micro. rar. sel. 511) (type)**. Fayette: Wilson 1909. (Wilson & Seaver Ascom. & Low. Fung. 99).

Synchytrium pluriannulatum (B. & C.) Farl, — Urophlyctis pluriannulata. Taphria coerulescens (Mont. and Desm.) Schröt, — Taphria coerulescens. Taphria johansonii (Sadeb.) Schröt. — Taphria johansonii.

Taphria virginica (Seym. & Sadeb.) Schröt. — Taphrina virginica.

834. Taphrina aurea (P.) Fr. (428, v. 8, p. 812)

On Populus sp. (10, 368).

On Populus balsamifera L. Ames: Pammel & Stewart 1892 (U. S. D. A. Div. Veg. Phys. & Path.)

On Populus berolinensis Dipp. (Populus certinensis Hort.) (366, 392). Ames: Pammel & Stewart 1892 (Seymour Herb.)

On Populus deltoides Marsh. (366, 383, 392)

835. Taphrina coerulescens (Mont. & Desm.) Tul. (518)

On Quercus sp. (15). Sac City: Archer & Layton 1927 (Survey 707)

On Quercus alba L. (406)

On Quercus palustris Moench. (522)

On Quercus rubra L. (522)

836. Taphrina johansonii Sadeb. (428, v. 10, p. 68)

On Populus tremuloides Michx. (522). Decorah: Holway 1892. Fayette: Wilson 1909 (Wilson & Seaver Ascom. & Low. Fung. 73). Poweshiek Co.: Conard 1921**.

Taphrina pruni Tul. - Exoascus pruni

837. Taphrina virginica Sevm. & Sadeb. (392)

On Ostrya virginiana (Mill.) K. Koch (10, 522). Boone: Pammel 1902**

838. Thecaphora aterrima Tul. (74, p. 43)

On Carex sp. (72, 74)

On Carex adusta Boott, (16, 53, 72, 245)

839. Tilletia corona Scribn. (74, p. 52)

On Leersia virginica Willd. Ames: Pammel 1909**.

840. Tilletia foetens (B. & C.) Trel. (74, p. 48)

On Triticum vulgare Vill. (wheat) (15, 72, 74, 191, 245, 352, 360, 376, 383, 389, 499). Ames: Crane 1896. Decatur Co.: Anderson 1913. Decorah: Holway 1884 (Ell. N. Amer. Fung. 1497)

Tilletia laevis Kühn. = Tilletia foetens

841. Tilletia maclagani (Berk.) Clint. (74, p. 50)

On Panicum virgatum L. (16, 72, 74, 245). Nevada: Pammel 1902. New Albin: Pammel 1897².

Tilletia rotundata (Arth.) Massee = Tilletia maclagani

¹Host erroneously reported by Raeder (410) as *Apios tuberosa*. ²Fide—G. P. Clinton.

Tilletia striaeformis Oud. = Ustilago striaeformis

Tilletia subfusca = Ustilago vilfae

842. Tilletia tritici (Bjerk.) Wint. (74, p. 48)

On Triticum vulgare Vill. (wheat) (15, 16, 72, 74, 199, 352, 389). Sac City: Conner 1902.

843. Tolyposporium bullatum Schroet. (74, p. 44)

On Echinochloa crus-galli (L.) Beauv. (16, 53, 72, 74, 245)

On Panicum dichotomiflorum Michx. (389)

Torrubia ravenelii Berk. - Corduceps ravenelii

* Tranzschelia punctata (Pers.) Arth. = Puccinia pruni-spinosae

844. Tubercularia vulgaris Tode (428, v. 4, p. 638) On Elaeagnus angustifolia L. Ames: Melhus 1924.

845. Tuberculina persicina (Ditm.) Sacc. (428, v. 4, p. 653)

On Puccinia caricis-asteris Arth, on Solidago latifolia L. (522)

On Puccinia eatoniae Arth, on Ranunculus abortivus L. Decorah: Holway 1883.

On Puccinia fraxinata (Schw.) Arth. on Fraxinus americana L. (522)

On Puccinia opizii Bubak on Lactuca canadensis L. (522)

On Puccinia peckii (DeT.) Kellerm. on Oenothera biennis L. (522)

On Puccinia phrymae (Halst.) Arth. on Phryma leptostachya L. (522)

Tuburcinia clintoniae Koern, on Polygonatum commutatum (R. & S.) Dietr. (Polygonatum giganteum) (72) = Urocystis colchici

Uncinula adunca Lev. — Uncinula salicis

Uncinula americana Howe — Uncinula necator

Uncinula ampelopsidis C. & Pk. = Uncinula necator

846. Uncinula circinata C. & P. (431)

On Acer sp. Decorah: Holway 1879 (Ell. N. Amer. Fung. 427)

On Acer glabrum Torr. (Acer barbatum) (389)

On Acer saccharinum L. (7, 8, 53, 197, 218). Decatur Co.: Anderson 1905. Stratford: Anderson 1913.

On Acer saccharum Marsh. (7, 10, 522). Ames: Carver 1894.

On Fraxinus pennsulvanica Marsh, var. lanceolata (Borkh.) Sarg. Ames: Bessey 1877.

847. Uncinula clintonii Pk. (431)

On Tilia americana L. (7, 171, 218, 522). Ames: Bessey 1878; Bettenga 1892; Carver 1894; Davis 1902; Thomas 1878. Decorah: Holway 1879. Union: Pammel 1913**. 848. Uncinula flexuosa Pk. (431)

On Aesculus hippocastanum L. (horsechestnut) (15). Osage: Archer 1927 (Survey 1389)

849. Uncinula geniculata Gerard (431)

On Morus rubra L. (7, 8). Decatur Co.: Anderson 1905. Uncinula heliciformis Howe — Uncinula salicis

850. Uncinula macrospora Pk. (431)

On Ulmus americana L. (7, 8, 171, 522). Decatur Co.: Anderson 1900. Decorah: Holway 1879 (Ell. N. Amer. Fung. 426) (Thüm. Myc. univ. 2053); 1888**.

On Ulmus racemosa Thomas (7, 8). Decatur Co.: Anderson 1905.

851. Uncinula necator (Schw.) Burr. (431)

On Psedera quinquefolia (L.) Greene (7, 8, 15, 53, 522). Ames: Bessey 1880; Carver 1892; Crane 1896; Hume 1899; Pammel 1910. DeWitt: Pammel 1898. Decatur Co.: Anderson 1904. Decorah: Holway 1879. Mondamin: Archer 1927 (Survey 1290)**

Ringgold Co.: Anderson 1905.

On Vitis sp. (7, 15, 53, 341, 342, 363, 376, 522). Ames: Pammel 1890; 1912; Raymond 1891 (conidia only). Boone: Pammel 1912.

On Vitis cordifolia Michx. (7, 522)

- On Vitis labrusca L. (7, 8, 171, 380, 383). Ames: Bettenga 1892 (conidia only); Pammel 1891 (conidia only); Rolfs 1891. Lebanon: Pammel 1918.
- On Vitis labruscana Bailey (grape). Monticello: Eastman 1913.

On Vitis rotundifolia Michx. Ames: Carver 1892. On Vitis vinifera L. Ames: Combs 1894 (conidia only)

On Vitis vulpina L. (199, 522)

852. Uncinula parvula Cook & Peck (431)

On Celtis occidentalis L. (12). Ames: Bessey 1878.

853. Uncinula salicis (DC.) Wint. (431) On Populus deltoides Marsh. (7)

- On Populus grandidentata Michx. (7). Columbus Jct.: Pammel 1899.
- On Populus tremuloides Michx. (7, 218). Decorah: Holway 1888**.
- On Salix sp. (7, 53, 218, 522). Ames: Bessey 1878. Decatur Co.: Anderson 1904. Decorah: Holway 1879 (Ell. N. Amer. Fung. 425)
- On Salix amygdaloides Anders. (7). Ames: Gray 1899; Anderson

On Salix cordata Muhl, Ames: Anderson 1913.

- On Salix discolor Muhl. (7). Ames: Ball 1898. Greenfield: Stewart 1893.
- On Salix humilis Marsh. (7, 522). Ames: Pammel 1899.

On Salix interior Rowlee. Ames: Combs 1894. 854. Uredinopsis osmundae Magn. (25, p. 115 and p. 683)

On Abies balsamea (L.) Mill. (25, 307). Delaware Co.: Macbride 1890*.

Uredo agrimoniae DC. = Pucciniastrum agrimoniae

Uredo boutelouae Arth. = Puccinia vexans

Uredo caeoma-nitens DeT. - Kunkelia nitens

Uredo campanulae (376) = Aecidium campanulastri

Uredo interstitialis Schlecht. = Gymnoconia interstitialis

Uredo iridis DC. = Puccinia iridis

Uredo polypodii Pers. on Cryptogamma stelleri = Hyalopsora cheilanthus 855. Urocystis agropyri (Preuss.) Schroet. (74, p. 58)

On Bromus ciliatus L. (72, 74, 245). Decorah: Holway 1883 (Seym.

& Earle Econ. Fung. 99)

On Elymus sp. Ames: King 1908; Stewart 1892.

On Elymus canadensis L. (16, 53, 72, 74, 245, 352, 368, 377, 380, 383, 406). Ames: Carver 1896**; Pammel 1890 (Seym. & Earle Econ. Fung. 100). Decorah: Holway 1884**.

On Elymus robustus S. & S. (72, 74, 245, 389). Ames: Pammel 1927; Walker 1896. Grinnell: Conard 1919**. Griswold: Dietz

1927 (Survey 796)

856. Urocystis anemones (Pers.) Schröt. (74, p. 55)

On Anemone quinquefolia L. (Anemone nemorosa L.) (16, 72, 522).

Ames: Gilman 1928 (Survey 1713). Decorah: Holway 1886**.

On Anemone virginiana L. (112, 245)

On Hepatica acutiloba DC. (16, 53, 72, 74, 197, 245, 522). Boone: Pammel 1913; Underwood 1924. Eldora: Conard 1921**. Ledges—Boone: Archer 1927 (Survey 635)**.

857. Urocystis cepulae Frost (74, p. 57)

On Allium cepa L. (cult. onion) (191, 376, 385). Conesville: Porter 1928 (Survey 1707). Pleasant Valley: Pammel 1911; Schutter 1911, 1914.

858. Urocystis colchici (Sehl.) Rabh. (74, p. 57)

On Polygonatum commutatum (R. & S.) Dietr. (16, 72, 74, 245)

859. Urocystis occulta (Wallr.) Rabenh. (74, p. 57)

On Sceale cereale L. (rye) (15, 191, 376). Centerville: Melhus 1916. Conesville: Archer 1927 (Survey 963)

Uromyces acuminatus Arth. = Uromyces polemonii Uromyces albus Diet, and Holw. = Uromyces porosus

860. Uromyces alliicolus (Wint.) Barth. (25, p. 227 and p. 747)

Syn. Nigredo alliicola (Wint.) Arth., Uromyces sporoboli Ell. & Ev.

On Allium canadense L. Decatur Co.: Anderson 1897-1909. (Not Uromyces bicolor Ell. as reported (8)). Iowa City: Hitchcock 1888*, 1889**.

On Sporobolus cryptandrus (Torr.) Gray. Sioux City: Pammel

1895.

On Sporobolus neglectus Wash. (31). Ames: Carver 1895. Hawarden: Pammel 1895. Sioux City: Pammel 1896.

861. Uromyces alopecuri Seym. (25, p. 227) Syn. Nigredo alopecuri (Seym.) Arth.

On Alopecurus geniculatus L. Galt: Archer 1927 (Survey 1229)

Arthur & Holway (32a) remark that this is apparently an uncommon northern species. The grass was growing in straw dump, beside a railroad embankment, near a swale. The uredospores measured $23\text{-}27 \times 20\mu$ and the pores were scattered.

Uromyces apiculatus Lev. — Uromyces fallens

862. Uromyces appendiculatus (Pers.) Lev. (25, p. 257)

Syn. Nigredo appendiculata (Pers.) Arth.

On Phaseolus sp. (342)

On Phaseolus vulgaris L. (cult. bean) (8, 15, 25, 31, 380, 383, 406). Ames: Carver 1892. Grinnell: Conard 1919**; Kel-

logg 1908. Lake Mills: Pammel 1918.

On Strophostyles helvola (L.) Britt. (Phaseolus diversifolius Pers.) (16, 25, 31, 53, 380, 384). Ames: Bessey 1878; Carver 1896**. Iowa City: Hitchcock 1887*. Mt. Pleasant: Mills 1897.

On Strophostyles pauciflora (Benth.) Wats. (384). Columbus Jct.: Pammel 1899.

¹Note: Dodge (183) refers the species of Urocystis to Tuburcinia, but the writers have kept the older usage as being better suited to the purposes of this paper.

On Vigna sinensis¹ (L.) Endl. (10, 25, 175, 372, 384). Ames: Rhinehart 1901.

863. Uromyces argophyllae Seym. (25, p. 447)

Syn. Pucciniola argophyllae (Seym.) Arth.

On Psoralca argophylla Pursh. (Psoralidium argophyllum (Pursh) Rydb.) (16, 25, 31). Decorah: Holway 1884*, **; 1886 (Barth. N. Amer. Ured. 994), Ibid.*

Uromyces arisaemae Cooke - Uromyces caladii

Uromyces brandegi Pk. = Puccinia vexans

864. Uromyces caladii (Schw.) Arth. (25, p. 236)

Syn. Nigredo caladii (Schw.) Arth.

On Arisaema dracontium L. (Muricanda dracontium (L.) Small) (8, 16, 25, 31, 522). Ames: Bessey 1881; Bettenga 1892; Carver 1892, 1896**; 1895; King 1911; Pammel 1890. Decatur Co.: Anderson 1904. Iowa City: Hitchcock 1887**. Manchester: Hoyt 1880. Spillville: Kovarik 1899 (Barth. N. Amer. Ured. 1586), Ibid.*, 1902*, 1902 (Barth. N. Amer. Ured. 1587), Ibid.*

On Arisaema triphyllum (L.) Shott. (8, 16, 25, 31, 522). Boone:
Anderson 1913; Underwood 1924. Decatur Co.: Anderson 1904. Decorah: Holway 1879, 1879*, 1886**, 1887**; 1892 (Syd. Ured. 752); 1885 (Barth. N. Amer. Ured. 882), Ibid.*, **; (Barth. N. Amer. Ured. 1090), Ibid.*. Manchester: Hoyt 1880. McGregor: Smith 1926. Muscatine: Pammel 1899. Winneshiek Co.: Goddard 1895.

865. Uromyces caryophyllinus (Schrank.) Wint. (25, p. 246)

Syn. Nigredo caryophyllina (Schrank.) Arth.

On Dianthus barbatus L. (cult. sweet william) (15). Ames:

Archer 1927 (Survey 1568)

On Dianthus caryophyllus L. (cult. carnation) (15, 25, 31, 341).

Ames: King 1912. Decorah: Holway 1895 (Barth. N. Amer. Ured. 1588), Ibid.*

Uromyces digitatus Halst. — Uromyces halstedii 866. Uromyces eleocharidis Arth. (25, p. 232)

Syn, Nigredo eleocharidis Arth.

On Eleocharis palustris (L.) R. & S. (31). Ames: Hitchcock 1889**. Emmet Co.: Cratty 1886 (Barth. N. Amer. Ured. 985)

Uromyces erythroni (DC.) Pass. on Allium canadense = Uromyces alliicolus

Uromyces erythroni (DC.) Pass, on Lilium superbum L. — Uromyces lilii Uromyces euphorbiae Cke. & Pk. — Uromyces proeminens

867. Uromyces fabae (Pers.) DeBy (25, p. 251)

Syn. Nigredo fabae (Pers.) Arth.

On Lathyrus myrtifolius Muhl. (25, 31)

On Lathyrus venosus Muhl. (16, 25, 31, 522). Decorah: Holway 1881*, 1885 (Barth. N. Amer. Ured. 788), Ibid.*, 1899 (Syd. Ured. 1353)*. Mason City: Holway 1883 (Ell. N. Amer. Fung. 1442), Ibid.*, 1884*.

¹Fromme (175) cites this specimen as being Nigredo vignae (Barcl.) From.

On Vicia americana Muhl. (31, 522). Decorah: Holway 1882*, 1888**.

Uromyces fabae on Apios tuberosa Moench, — Aecidium onobrychidis Uromyces fabae on Vicia americana Muhl. — Uromyces porosus in part Uromyces fabae on Psoralea argophylla Pursh — Uromyces argophyllae 868. Uromyces fallens (Desm.) Kern (25, p. 254; 280)

Syn. Nigredo fallens (Desm.) Arth.

On Trifolium pratense L. (red clover) (8, 15, 25, 31, 336, 352, 355, 361, 368, 372, 380, 406). Ames: Bettenga 1892; Carver 1894; Chestek 1894; Fawcett 1902; King 1910, 1911; Paddock 1901; Pammel 1890**, 1909, Boone: Coe 1912. Decatur Co.: Anderson 1895. Decorah: Holway 1891 (Barth. N. Amer. Ured. 1590), Ibid.*; (Barth. N. Amer. Ured. 1091), Ibid.* Grundy Center: Archer 1927 (Survey 1418)

Uromyces gaurinus (Pk.) Long — Uromyces plumbarius

869. Uromyces gentianae Arth. (25, p. 264)

Syn. Nigredo gentianae Arth.

On Gentiana quinquefolia var. occidentalis (Gray) Hitchc. (Amarella occidentalis (Gray) Greene) (18, 25, 31). Decorah: Holway 1884 (Barth. N. Amer. Ured. 385), Ibid.*, 1885*.

Uromyces geranii (DC.) O. & W. on Geranium maculatum L. reported by Anderson (8) can be only Puccinia polygoni-amphibii.

870. Uromyces glycyrrhizae (Rabenh.) Magn. (25, p. 478)

Syn. Klebahnia glycyrrhizae (Rabenh.) Arth.

On Glycyrrhiza lepidota Nutt. Jordan: Pammel 1927 (Survey 805)

871. Uromyces graminicola Burr. (25, p.224)

Syn. Nigredo graminicola (Burr.) Arth.

On Panicum virgatum L. (25, 31, 352). Ames: Bessey 1877; Carver 1892; Hume 1899; Miller 1890; Pammel 1889, 1899, 1901; Wright 1892. Decorah: Holway 1885 (Arth. & Holw. Ured. Exsic. 19b). Iowa City: Hitchcock 1888**.

872. Uromyces halstedii De T. (25, p. 226) Syn. Nigredo halstedii (DeT.) Arth.

> On Leersia virginica Willd. (Homolocenchrus virginicus (Willd.) Britt.) (25, 31, 46, 199). Ames: Halsted 1887 (Ell. & Ev. N. Amer. Fungi 2nd Ser. 2227). Decorah: Holway 1901*.

873. Uromyces hedysari-paniculati (Schw.) Farl. (25, p. 248)

Syn. Nigredo hedysari-paniculati (Schw.) Arth.

On Desmodium canadense (L.) DC. (25). Decorah: Holway 1884*, 1888**.

On Desmodium dillenii Darl. (25, 31)

On Desmodium sessilifolium (Torr.) T. & G. (Meibomia sessilifolia (Torr.) Kuntze) (16, 25, 31, 53)

874. Uromyces hordei Tracy (25, p. 228 and p. 749)

Syn. Nigredo hordeina (Tracy) Arth.

On Hordeum pusillum L. Randolph: Archer 1927 (Survey 882)

875. Uromyces howeii Pk. (25, p. 264) Syn. Nigredo howei (Pk.) Arth.

On Asclepias incarnata L. (16, 25, 31)

On Asclepias syriaca L. (Asclepias cornuti Dene.) (8, 16, 25, 31,

Anderson 1903, Decorah: Holway 1878*, 1881*, 1885*, **, 1888 (Syd. Ured. 255), Ibid.*, **.

On Asclepias tuberosa L. (10, 16, 25, 31). Decorah: Holway

1881*.

Uromyces hybridi Davis = Uromyces trifolii

876. Uromyces hyperici-frondosi (Schw.) Arth. (25, p. 261)

Syn. Nigredo hyperici-frondosi (Schw.) Arth.

On Hypericum ascyron L. (Hypericum pyramidatum Ait.) (16, 25, 31, 53). Ames: Bessey 1879. Decorah: Holway 1879; 1884 (Barth, N. Amer, Ured, 291), Ibid,*: 1884 (Barth, N. Amer, Ured. 390). Ibid.*

On Hypericum mutilum L. (25) On Hypericum virginicum L. (25)

877. Uromyces junci (Desm.) Tul. (25, p. 238 and p. 753)

Syn, Nigredo junci (Desm.) Arth.

On Helianthus occidentalis Riddell (25, 31). Decorah: Holway 1888 (Barth. N. Amer. Ured. 1050), Ibid.*; 1899 (Syd. Ured, 1394)*. Jackson: Holway 1886 (Seym. & Earle Econ. Fung. 52), Ibid.*

878. Uromyces lespedezae-procumbentis (Schw.) Curt. (25, p. 247)

Syn. Nigredo lespedezae-procumbentis (Schw.) Arth.

On Lespedeza capitata Michx, (16, 25, 31, 522). Ames: Bessey 1876. Decorah: Holway 1888 (Syd. Ured. 306)

On Lespedeza leptostachya Engelm. (16, 25, 31, 522). Bessey 1872. Decorah: Holway 1884 (Barth. N. Amer. Ured. 892), Ibid.*, 1888**. Emmet Co.: Cratty 1892*.
879. Uromyces lilii G. W. Clint. (25, p. 242)

Syn. Nigredo lilii (G. W. Clint.) Arth.

On Lilium superbum L. (16, 25, 31). Decorah: Holway 1884*.

880. Uromyces medicaginis Pass. (25, p. 256) Syn. Nigredo medicaginis (Pass.) Arth.

> On Medicago sativa L. (alfalfa) (15, 25, 29, 31, 374, 376, 385, Ames: Coe 1910, 1911; Pammel 1911. Oakland: Archer 1927 (Survey 1586). Webster City: Melhus 1923.

881. Uromyces minutus Diet. (25, p. 234) Syn. Nigredo minuta (Diet.) Arth.

> On Carex pubescens Muhl. (21, 25, 31). Decorah: Holway 1887 (Barth. N. Amer. Ured. 893), Ibid.*

Uromyces orobi on Lathyrus venosus = Uromyces fabae Uromyces orobi on Vicia americana — Uromyces porosus 882. Uromyces perigynius Halsted (25, p. 235 and 752)

Syn. Nigredo perigunius (Halst.) Arth.

On Carex intumescens Rudge (25, 31, 353). Ames: Halsted -(Ell. & Ev. N. Amer. Fung. 2nd Ser. 2228), Ibid.*; 1889 (Barth. N. Amer. Ured. 1094), Ibid.* Winneshiek Co.: Goddard 1895.

On Rudbeckia laciniata L. (10, 16, 25, 31, 522). Ames: Hitchcock 1885-6. Decorah: Holway 1879; 1886 (Barth. N. Amer. Ured, 701), Ibid.*: —— (Ell. N. Amer. Fung, 1018), Ibid.*; 1887 (Syd. Ured. 97), Ibid.* Winneshiek Co.: Goddard 1895.

On Rudbeckia laciniata var. hortensia Bailey (cult. goldenglow).
Grinnell: Conard 1906**.

Arthur (21) referred a rust on Carex pubescens Muhl. from Iowa to this species, but later transferred this form to Uromyces minutus Diet. Uromyces phaseoli on Strophostyles helvola (L.) Britt. — Uromyces appen-

diculatus

883. Uromyces plumbarius Peck (25, p. 262)

Syn. Nigredo plumbaria (Pk.) Arth.

On Gaura biennis L. Greenfield: Archer 1927 (Survey 1123). Vail: Archer 1927 (Survey 1243)

On Oenothera biennis L. (16, 25, 31). Ames: Halsted 1885**. Decorah: Holway 1882*, 1883**.

884. Uromyces polemonii (Pk.) Barth. (25, p. 231)

Syn. Nigredo polemonii (Pk.) Arth.

On Phlox sp. (10)

On Phlox divaricata var. laphamii Wood (16, 25, 31). Ames: Hitchcock 1886; Thomas 1879.

On Phlox paniculata L. (25, 31)

- On *Phlox pilosa* L. (16, 25, 31). *Ames:* Bessey 1881; Hitchcock 1885-6; Hume 1899. *Decatur Co.:* Anderson 1900. *Decorah:* Holway 1879*. *Story City:* Raleigh 1927 (Survey 614).
- On Polemonium reptans L. (16, 25, 31, 336, 522). Decatur Co.:
 Anderson 1900. Decorah: Holway 1879, 1879*, 1879
 (Rabenh. Wint. Fung. eur. 3637)*; Holway 1882 (Ell. N. Amer. Fung. 1008), Ibid.*, 1885 (Barth. N. Amer. Ured. 597), Ibid.* Grinnell: Conard 1923**. Iowa City: Hitchcock 1889**.
- On Spartina michauxiana Hitche. (Spartina cynosurioides A. Gray) (16, 25, 28, 31, 34, 53, 522). Ames: Carver 1892; 1899**; Wright 1892. Boone: Archer 1927 (Survey 1172). Decorah: Holway 1883 (Ell. N. Amer. Fung. 1443), Ibid.*; 1884 (Arth. & Holw. Ured. Exsic. 52b); 1885 (Syd. Ured. 251). Spirit Lake: Arthur 1883 (Rabenh. Wint. Fung. eur. 3623)*, **; 1898 (Arth. & Holw. Ured. Exsic. 52a), 1883 (Ibid. 52e); 1904**.

On Steironema ciliatum (L.) Raf. (Lysimachia ciliata) (25). Ames: Bessey 1880; Hitchcock 1886. Little Wall Lake: Hayden 1924.

885. Uromyces polygoni (Pers.) Fckl. (25, p. 243)

Syn, Nigredo polygoni (Pers.) Arth.

On Polygonum aviculare L. (16, 25, 31, 53, 380). Ames: Carver 1896**; Diehl 1915. Decorah: Holway 1886 (Barth. N. Amer. Ured. 1095), Ibid.* Winneshiek Co.: Goddard 1895.

On Polygonum crectum L. (16, 25, 31, 380). Ames: Carver 1892; Halsted 1885**. Decorah: Holway 1886 (Barth. N. Amer. Ured. 991), Ibid.* Winneshiek Co.: Goddard 1895.

On Polygonum ramosissimum Michx. (25, 31). Jewell Jct.: Hitchcock 1885-6.

Uromyces polymorphus on Vicia americana — Uromyces porosus

886. Uromyces porosus (Pk.) Jacks. (25, p. 450)

Syn. Pucciniola porosa (Pk.) Arth.

On Vicia americana Muhl. (16, 25, 31, 53, 522). Ames: Bessey 1882; Carver 1894; 1896**; Halsted 1885**; Hitchcock 1885-6. Decorah: Holway 1882, 1882*, 1884*, 1885*, 1885 (Barth. N. Amer. Ured. 981), Ibid.* Eldora: Pammel 1927 (Survey 617). Floyd Co.: Smith 1926.

On Vicia sparsifolia Nutt. (25, 31)

887. Uromyces proeminens (DC.) Pass. (25, p. 259)

Syn. Nigredo proeminens (DC.) Arth.

On Euphorbia sp. Spirit Lake: Halsted 1885**.

On Euphorbia dentata Michx. (Poinsettia dentata (Michx.) Small) (25, 31)

On Euphorbia glyptosperma Engelm, (Chamaesyce glyptosperma

(Engelm.) Small) (16, 31)

- On Euphorbia heterophylla L. (Poinsettia heterophylla (L.) Kl. & Gareke) (16, 25, 31). Decorah: Holway 1879, 1879*. Sioux City: Bartholomew (Barth, N. Amer. Ured, 2797).
- On Euphorbia humistrata Engelm. (Chamaesyce humistrata (Engelm.) Small) (25, 31, 522). Ames: Carver 1892.
- On Euphorbia maculata L. (Chamaesyce maculata (L.) Small) (8, 16, 25, 31, 53, 380). Ames: Bettenga 1892; Bakke 1907; Bessey 1876; Hitchcock 1885-86; King 1911; Pammel 1909. Boone: Pammel 1890. Decatur Co.: Anderson 1904. Decorah: Holway 1878*, 1886**, 1887 (Barth. N. Amer. Ured. 895), Ibid.* Turin: Pammel 1894. Winneshiek Co.: Goddard 1895.
- On Euphorbia marginata Pursh, (Dichrophyllum marginatum (Pursh) Kl. & Garcke.) (15, 25, 31, 53). Mondamin: Archer 1927 (Survey 1291)

On Euphorbia polygonifolia L. Lake Okoboji: Conard 1923**.

On Euphorbia preslii Guss. (Euphorbia hypericifolia L.) (Chamaesyce preslii (Guss.) Arth.) (16, 25, 31, 53, 380). Ames: Bessey 1875; Cratty 1925; Carver 1892; 1896**; Gilman 1927 (Survey 904); Halsted 1885**; Hitchcock 1885-86; Hume 1899; King 1910; 1912. Council Bluffs: Bartholomew 1913 (Barth. Fung. Col. 4194). Jefferson: Pammel 1895. Sioux City: Pammel 1895.

On Euphorbia serpyllifolia Pers. (Chamaesyce serpyllfolia

(Pers.) Small) (25, 31)

888. Uromyces pyriformis Cke. (25, p. 237) Syn. Nigredo pyriformis (Cke.) Arth.

> On Acorus calamus L. (16, 25, 31, 522). Ames: Blake 1899. Decorah: Holway 1884 (Barth. N. Amer. Ured. 699), Ibid.*

889. Uromyces rudbeckiae Arth. & Holw. (25, p. 519)

Syn. Teleutospora rudbeckiae (A. & H.) Arth. & Bisby.

On Rudbeckia laciniata L. (16, 25, 31, 53, 522). Decorah: Holway 1884 (Arth. & Holw. Ured. Exsic. 1) (Ell. N. Amer. Fung. 1439), Ibid.*; 1885 (Syd. Ured. 1305)*. Spirit Lake: Halsted 1885**. Winneshiek Co.: Goddard 1895.

890. Uromyces scirpi (Cast.) Burr. (25, p. 233)

Syn. Nigredo scirpi (Cast.) Arth.

On Cicuta maculata L. (16, 25, 31)

On Scirpus atrovirens Muhl. Ames: Carver 1892.

On Scirpus fluviatilis (Torr.) Gray (25, 31). Ames: Hume 1899. Hancock Co.: Holway 1883*.

On Sium cicutaefolium Schrank.1

891. Uromyces seditiosus Kern. (25, p. 225) Syn. Nigredo seditiosa (Kern) Arth.

On Plantago aristata Michx. Decatur Co.: Anderson 1901.

892. Uromyces silenes (Schlecht.) Fckl. (25, p. 247) Syn, Nigredo silenes (Schlecht.) Arth.

On Silene nivea (Nutt.) Arth. (25, 31)

893. Uromyces silphii (Syd.) Arth. (25, p. 239)

Syn. Nigredo silphii (Syd.) Arth.

On Juncus interior Wiegand (25, 31, 522)

On Juncus tenuis Willd. (8, 16, 25, 31, 53). Ames: Bessey 1878; Hodson 1899. Decatur Co.: Anderson 1904. Decorah: Holway 1886 (Barth. N. Amer. Ured. 997), Ibid.* Jackson: Holway 1886 (Seym. & Earle Econ. Fung. 52)

On Silphium laciniatum L. (8, 16, 25, 31, 522). Ames: Hitchcock 1885-86. Clarion: Melhus 1907, 1909**. Decatur Co.: Anderson 1904. Decorah: Holway 1887**. Spirit Lake: Halsted 1885**.

On Silphium perfoliatum L. (16, 25, 31)

894. Uromyces sparganii Cke. & Pk. (25, p. 222 and p. 745)

Syn. Nigredo sparganii (Cke. & Pk.) Arth.

On Sparganium eurycarpum Engelm. (16, 25, 31). Garner: Holway 1883**.

Uromyces sporoboli Ell. & Ev. — Uromyces allicolus Uromyces striatus Schröt. — Uromyces medicaginis

Uromyces terebinthii (DC.) Wint. = Uromyces toxicodendri

895. Uromyces toxicodendri Berk. & Rav. (25, p. 147) Syn, Pileolaria toxicodendri (Berk. & Rav.) Arth.

On Rhus radicans L. (25, 31). Decorah: Holway 1878*, 1885 (Barth. N. Amer. Ured. 813), Ibid.*

On Rhus toxicodendron L. (8, 16, 53, 522). Ames: Hitchcock 1889**. Decatur Co.: Anderson 1904. West Okoboji: Martin 1925**.

896. Uromyces trifolii-repentis (Cast.) Liro (25, p. 255)

Syn. Nigredo trifolii (Hedw. f.) Arth.

On Trifolium sp. (376)

On Trifolium hybridum L. (alsike clover) (15, 25, 94). Fayette Co.: Smith 1927 (Survey 990)**

On Trifolium incarnatum L. (352, 361, 383)

On Trifolium repens L. (15, 16, 25, 31, 383, 406, 522). Ames: Halsted 1885**; Hitchcock 1885-6. Decorah: Holway 1886

¹Pammel collected the aecidial stage of this rust at Simmons Mills, Minnesota, in July, 1928, and doubtless it occurs on this host in Iowa, but has yet to be found.

(Barth. N. Amer. Ured. 500), Ibid.* Floyd Co.: Smith 1926. Oelwein: Archer 1927 (Survey 554)

The specimens of Uromyces on Trifolium pratense L, are referred to

Uromyces fallens following Kern (280).

897. Uromyces zygadeni Pk. (25, p. 240 and p. 754)

Syn, Nigredo zygadeni (Pk.) Arth.

On Zygadenus chloranthus Richards (25)

898. Urophlyctis pluriannulata (B. & C.) Farl. (170)

On Sanicula marilandica L. Decorah: Holway 1885, 1888**.

On Zizia aurea (L.) Koch. Ames: Catlin 1923.

899. Uropyxis amorphae (M. A. Curt.) Schröt. (25, p. 158)

On Amorpha canescens Pursh. (8, 16, 25, 31, 53). Ames: Bessey 1878, 1880. Decorah: Holway 1884*, 1884 (Barth, N. Amer.

Ured. 1399), Ibid.*, 1885*.

On Amorpha fruticosa L. (16, 25, 31, 522). Ames: Bessey 1876, 1878; Carver 1892. Decorah: Holway 1889*, 1889 (Ell. & Ev. N. Amer. Fung. 1036), Ibid.* Little Rock: Pammel 1918, Winneshiek Co.: Goddard 1895.

On Amorpha microphylla Pursh. (Amorpha nana Nutt.) (16, 25, 31).

900. Uropyxis petalostemonis (Farl.) DeT. (25, p. 156)

On Petalostemum purpureum (Vent.) Rydb. Conesville: Archer 1927 (Survey 981).

901. Ustilago arthurii Hume (74, p. 20)

On Glyceria grandis S. Wats. (74, 245). Spirit Lake: Arthur 1899 (Seym. & Earle Econ. Fung. C. 135).

Ustilago austro-americana Speg. - Melanopsichium austro-americanum.

902. Ustilago avenae (Pers.) Jens. (74, p. 7)

On Avena sativa L. (oats) (8, 15, 16, 53, 74, 191, 245, 352, 361, 368, 376, 380, 383, 388, 389, 406). *Ames:* Anderson and Pammel 1913; Carver 1896**; Clapper 1906; Hume 1900; King 1908, 1912; Paddock 18971; Pammel 1909, 1911; Stewart —; Welch 1900. Boone: Coe 1912. Homestead: Martin 1923**. Mason Citu: Pammel 1908.

903. Ustilago bromivora (Tul.) Fisch. d. Waldh. (74, p. 10)

On Bromus breviaristatus (Hooker) Buckl. (Bromus marginatus Nees.) (72, 74, 245, 352, 361, 389).

On Bromus ciliatus L. (72). Sac City: Conner 1902.

On Bromus inermis Leyss. (Hungarian brome grass) (10)²

Ustilago candollei Tul. = Sphacelotheca hydropiperis.

Ustilago caricis Ung. — Cintractia caricis.

904. Ustilago crameri Körn. (74, p. 10)

On Setaria italica (L.) Beauv. (245, 383). Mt. Sterling: Pammel. Seymour: Sager 19081.

Fide-G. P. Clinton.

²This report is based on a specimen that has since been changed from Ustilago bromivora var. macrospora to Ustilago macrospora.

905. Ustilago hordei (Pers.) Kellerm. & Sw. (74, p. 6)

On Hordeum vulgare L. (15, 74, 191, 245, 341, 352, 368, 376, 380, 383, 389, 406, 522). Ames: Bettenga 1892¹; Carver 1896**. Red Oak: Dodge 1917**.

906. Ustilago hypodytes (Schlecht.) Fr. (74, p. 5) On Elymus canadensis L. (16, 53, 72, 74, 389).

Ustilago junci Schw. = Cintractia junci.

907. Ustilago levis (K. & S.) Magn. (74, p. 7)

On Avena sativa L. (72, 74, 376, 389). Ames: Hume 1900; Lummis 1900; King 1914; Paddock 1900; Pammel & Anderson 1913. Ontario: Faurot 1900.

908. Ustilago longissima (Sow.) Tul. (74, p. 6)

On Glyceria sp. (245).

On Glyceria grandis S. Wats. (72, 74, 389). Galt: Archer 1927 (Survey 1222). Winneshiek Co.: Goddard 1895.

909. Ustilago macrospora Desm. (74, p. 19) On Agropyron repens (L.) Beauv. (72).

On Bromus inermis Leyss. (Hungarian brome grass) (10, 72) Ames: Hayden 1909**1.

Ustilago maydis = Ustilago zeae

910. Ustilago minima Arth. (74, p. 5)

On Stipa spartea Trin. (16, 53, 72, 74, 245, 368, 380, 389) Ames: Carver 1896**; Paddock 1896¹; Stewart 1892 (Seym. & Earle Econ. Fung. C 70). Grinnell: Fink 1905**¹.

This fungus was listed by Clinton (72) as Ustilago hypodytes.

911. Ustilago neglecta Niessl. (74, p. 16)

On Setaria sp. Decorah: Holway 1888**.

On Setaria glauca (L.) Beauv. (8, 16, 53, 72, 245, 352, 368, 380, 389, 522). Ames: Anderson 1913; Brown 1896; Carver 1896**; Clokey 1922; Combs 1894; Crane 1896; Hodson 1899; Hume 1898; King 1908, 1912; Pammel 1899, 1910; Paddock 1901; Walker 1896; Wright 1892. Boone: Coe 1912. Des Moines: Pammel 1900, 1903. Marshalltown: Pammel 1902. Mondamin: Archer 1927 (Survey 1253)**. Nevada: Reed 1918**. Turin: Pammel 1894*.

On Setaria viridis (L.) Beauv. (383).

912. Ustilago nuda (Jens.) Kellerm. & Sw. (74, p. 8)

On Hordeum vulgare L. (15, 16, 53, 191, 245, 361, 368, 376, 380, 383, 389, 406). Ames: Hume 1900; King 1908, 1909, 1912; Paddoek 1897¹; Pammel 1909, 1911. Decorah: Holway 1884**.

913. Ustilago oxalidis Ell. & Tr. (74, p. 20)

On Oxalis stricta L. (74, 245). Ames: Carver 1900.

Ustilago panici-glauca = Ustilago neglecta.

Ustilago panici-miliacea = Ustilago rabenhorstiana.

¹Fide—G. P. Clinton.

914. Ustilago perennans Rostr. (74, p. 7)

On Arrhenatherum elatius (L.) Beauv. (16, 72, 74, 197, 245, 361, 368, 380, 389). Ames: Carver 1896**; Crane 1896; Sirrine & Pammel 1890 (Seym. & Earle Econ. Fung. 83); Stewart 1892¹; Walker 1896. Ames: Halsted 1893 (Ell. & Ev. N. Amer. Fung. 2nd Ser. 1893b).

915. Ustilago pustulata Tr. & Earle (74, p. 14)

On Panicum dichotomiflorum Michx. (72, 74, 245, 380).

916. Ustilago rabenhorstiana Kuhn. (74, p. 17)

On Digitaria humifusa Pers. (16, 245). Ames: Pammel 1910.

On Digitaria sanguinalis (L.) Scop. (Panicum sanguinale) (8, 72, 74, 245, 361, 368, 380, 406, 522). Ames: Combs 1894; Halsted 1885**; Hume 1898; Sample 1898**; Stewart 1892¹; Wright 1892¹. Conesville: Gilman & Layton 1927 (Survey 1156)**. Lamoni: Anderson 1913.

On Panicum capillare L. (16, 53, 352, 361).

On Panicum dichotomiflorum Michx. (8, 245).

Ustilago reiliana = Sorosporium reilianum.

Ustilago segetum on Arrhenatherum elatius (L.) Beauv. — Ustilago perennans; on Avena sativa L. — Ustilago avenae; on Hordeum vulgare L. —Ustilago hordei; on Triticum vulgare Vill. — Ustilago tritici.

917. Ustilago sieglingiae Ricker (74, p. 12)

On Triplasis purpurea (Walt.) Chapm. (308). Big Mound, Louisa Co.: Adams & Martin 1928.

 $Ustilago\ sorghi = Sphacelotheca\ sorghi.$

918. Ustilago spermophora B. & C. (74, p. 12)

On Eragrostis megastachya (Koeler) Link. (Eragrostis major Hort.) (16, 53, 72, 74, 245, 389). Ames: Hodson 1899. Charles City: Arthur 1882 (Ell. & Amer. Fung. 1098). Decorah: Holway 1888 (Barth. Fung. Col. 4300).

919. Ustilago sphaerogena Burr. (74, p. 14)

On Echinochloa crus-galli (L.) Beauv. (Panicum crus-galli) (72, 245, 389). Ames: Pammel 1909.

920. Ustilago striaeformis (West.) Niessl. (74, p. 18)

On Agropyron repens (L.) Beauv. (377, 389).

On Agrostis alba L. (72, 74, 245). Ames: Carver 1896**. Clarinda: Plagge 1919.

On Elymus virginicus L. Conesville: Layton 1927 (Survey 1030).

On Festuca nutans Willd. Ames: Fritzel 1929.

On Phleum pratense L. (timothy grass) (15, 72, 74, 191, 245, 342, 352, 361, 368, 377, 380, 383, 389, 406). Ames: Carver 1896**; Pammel 1889, 1892*, 1902, 1906**. Des Moines: Pammel 1895. Oelwein: Archer 1927 (Survey 562).

On Poa pratensis L. (blue grass) (15, 72, 245, 352, 361, 377). Ames:

Carver 1896**; Pammel 1889.

 $Ustilago\ syntherismae = Sorosporium\ syntherismae.$

^{&#}x27;Fide-G. P. Clinton.

921. Ustilago tritici (Pers.) Jens. (74, p. 8)

On Triticum vulgare Vill. (wheat) (8, 15, 16, 53, 74, 191, 245, 360, 361, 368, 380, 383, 389). Ames: Anderson 1913; Brown 1896; Capper 1906**; Carver 1896**; Crane 1896; King 1912; Paddock 1897¹; Pammel 1909, 1911**. Ledges-Boone: Coe 1912.

922. Ustilago utriculosa (Nees) Tul. (74, p. 22)

On Polygonum aviculare L. (72).

On Polygonum hydropiper L. (16, 72, 74, 245).

On Polygonum lapathifolium L. (8, 16, 53, 72, 245, 522). Ames: Bet-

tenga 18921, Sample 1898**.

On Polygonum pennsylvanicum L. (8, 16, 53, 72, 74, 197, 245, 522).

Ames: Crane 1896; King 1909; 1915. Des Moines: Pammel 1902.

Grinnell: Conard 1921**. Iowa City: Hitchcock 1889**. Marshalltown: Pammel 1902. Mt. Vernon: Pammel 1927. Sioux City: Pammel 1927.

On Polygonum persicaria L. Decorah: Archer 1927 (Survey 1461).

923. Ustilago vilfae Wint: (74, p. 17)

On Sporobolus neglectus Nash. (72, 74).

924. Ustilago zeae (Beckm.) Unger (74, p. 15)

On Euchlaena mexicana Schrad. (teosinte) (10, 72). Ames: Sample 1898**.

On Zea mays L. (8, 15, 16, 53, 74, 191, 197, 245, 352, 353, 358, 361, 368, 376, 380, 381, 383, 388, 389, 406). Ames: Anderson 1913; Bettenga 1892; Combs 1894; Crane 1896; Howe 1900; Morrison 1900; Paddock 1897; Sample 1898**.

On Zea mays var. everta Bailey (pop corn) (15).

On Zea mays var. indentata Bailey (corn) (15).

On Zea mays var. rugosa Bonaf. (sweet corn) (15, 191).

Ustilago zeae-mays = Ustilago zeae.

925. Venturia cerasi (Rabenh.) Aderh. (3, 51)

Syn. Cladosporium cerasi (Rabenh.) Sacc. On Prunus sp. (cult. cherry) (406).

On Prunus cerasus L. (363, 365, 383). Ames: Pammel & Stewart 1892 (Seym. & Earle Econ. Fung. 423).

926. Venturia inaequalis (Cooke) Aderh. (508)

On Pyrus ioensis (Wood) Bailey (8, 10, 15, 522). Ames: Pammel & Stewart 1892 (Seymour & Earle, Ec. Fungi 420). Indianola: Archer 1927 (Survey 1076).

On Pyrus ioensis plena Ar. (cult. Bechtel crab) (15).

On Pyrus malus L. (apple) (8, 15, 191, 355, 376, 383). Ames: Mc-Clelland 1889; Pammel 1909; Rolfs 1891. Ledges-Boone: Coe 1912. Cedar Falls: Wilbur 1914. Clarinda: Maney 1912. Decorah: Holway 1884. McGregor: Archer 1927 (Survey 547).

On Pyrus soulardi Bailey (8). Decatur Co.: Anderson 1900. Venturia occidentalis E. & E. = Acanthostiqma occidentalis.

Venturia pomi = Venturia inaequalis.

¹Fide-G. P. Clinton.

927. Venturia pyrina Aderh. (1)

On Pyrus communis L. (pear) (15). McGregor: Evans 1927 (Survey 1034). Postville: Schultz 1914.

928. Venturia tremulae (Frank.) Aderh. (2, 174, 234)

Syn. Cladosporium asteroma Fckl.; Napicladium asteroma (Fckl.) Allesch., forma: Cladosporium asteroma Fckl.; Napicladium asteroma (Fckl.) Allesch., forma: Fusicladium tremulae Frank.; Cladosporium subsessile Ell. & Barth., Fusicladium radiosum (Lib.) Lind.

On Populus sp. (15). Jones Co.: Porter 1927 (Survey 808).

On Populus deltoides Marsh. Ames: Pammel 1910.

On Populus grandidentata Michx. Ames: Anderson 1913.

Exsic. cited: Thum. Myc. univ. 1170; Allescher & Schnabl (Fung. bay. 596 & 597); Clements (Cryptog. Form. Colo. 67 & 506); Davis (Fung. Wis. 94); Barth. (Kans. Fung. 1576) (Type of Cladosporium subsessile); Ell. & Ev. (N. Amer. Fung. 2nd Ser. 3288).

Examination of the exsiccati cited show our specimens to be the same as Napicladium tremulae (Frank) Sacc. which according to the European workers (2, 174, 234) is synonymous with Napicladium asteroma (Fckl.) Allesch, as shown by his exsiccati (Fung. bav. 596-597). This fungus was connected with Venturia tremulae by Aderhold (2). Further examination of the exsiccati of Cladosporium subsessile Ell. & Barth, showed this species to be identical.

Vermicularia sanguinea = Colletotrichum graminicolum.

929. Verticillium albo-atrum Reinke & Berthold (312)

On Rhus canadensis Marsh, var. trilobata (Nutt.) Gray. Ames: Melhus 1928.

On Rhus glabra L. Ames: Melhus 1928. On Rhus typhina L. Ames: Melhus 1928.

930. Verticillium agaricinum (Link) Cda. (294)

On Polyporus versicolor Fr. Ames: Pammel 1923.

931. Verticillium rexianum Sacc. (428, v. 2, p. 153) On Arcuria denudata (L.) Sheld. Ames: Gilman 1921.

932. Vibrissia hypogeae Richon (419a) Syn. Coniocybe nivea (Hoffm.) Rehm. On Vitis sp. (361).

933. Volutella dianthi (Hals.) Atk. (38)

On Dianthus plumarius L. Boone Co.: Nichols 1929.

934. White spot (non-parasitic) (81, 335)

On Medicago sativa L. Jessup: Falk 1928 (Survey 1715).

935. Wind whipping

On Rubus spp. (cult. raspberry) (15).

936. Winter injury

On Medicago sativa L. (alfalfa) (15).

On Pinus strobus L. (white pine) (15).

On Prunus cerasus L. (cult. cherry) (15).

On Pyrus malus L. (cult. apple) (15).

On Rubus spp. (cult. raspberry) (15).

On Rubus allegheniensis Porter (cult. blackberry) (15).

On Syringa sp. (cult. lilac) (15).

937. Yellows (leaf-hopper)

On Medicago sativa L. (alfalfa) (15). Jewell: Archer 1927 (Survey 1338).

938. Yellows (virus) (287)

On Callistephus chinensis Nees. (cult. aster) (15).

EXCLUDED SPECIES

Albugo bliti (Biv.) Ktze. (410) on Acnida cannabina L.

Alternaria brassicae (Berk.) Sacc. (15) on Radicula armoracia (L.) Robinson.

Bacillus cloaceae Jordan (368, 380, 381, 383, 389) on Zea mays L.

Bacterium mali Brz. (338) on Pyrus malus L.

Cenangium abietis (Pers.) Rehm. (189) on Pinus strobus L.

Cephalosporium sacchari (406) on Zea mays L.

Cercospora cruenta (10, 406) on Lycopersicon esculentum L.

Cercospora syriaca L. (522) on Asclepias syriaca L.

Erysiphe cichoracearum DC. (189, 199) on Taraxacum officinale Weber.

Fusarium betae (356) on Beta vulgaris L.

Fusarium gentianus (376) on Brassica oleracea L.

Gymnosporangium juniperinum (L.) C. Mart. (10) on Juniperus spp.

Leptosphaeria phlogis (10) on Phlox sp.

Microsphaera alni (Wallr.) Salm. (363) on Symphoricarpos sp.

Mycosphaerella fragariae (Tul.) Lind. (189) on Potentilla monspeliensis L. Peronospora trifoliorum DeBy. (54, 197, 202, 352, 410) on Vicia americana Muhl.

Peronospora violae (410) on Viola sp. The specimen upon which this report was based proved to be Sphaerotheca humuli.

Phoma sp. (10) on Cupressus glabra Sudw.

Phoma sp. (10) on Thuja orientalis L.

Phoma pomi Pass. (10) on Pyrus malus L.

Puccinia coronata Cda. (16) on Phalaris arundinacea L.

Puccinia globosipes Pk. (406) on Lycium halimifolium Mill.

Puccinia intermixta Pk. (336a) on Iva xanthiifolia Nutt.

Puccinia minuta Dietel (282) on Carex sp.

Puccinia phragmites (Schum.) Wint. on Spartina sp.

Septoria alliorum West. (502) on Allium porrum L.

Septoria cerasina Pk. (502) on Prunus pennsylvanica L. f.

Septoria oculata E. & K. (522) on Vernonia altissima Nutt.

Septoria smilacina Dur. & Mont. (502) on Smilax herbacea L. Sphaerotheca pannosa Lev. (53) on Ribes grossularia L.

Sphaerotheca pannosa Lev. (218) on Ribes rotundifolia Michx.

Uromyces bicolor Ell. (8) on Allium canadense L.

Uromyces geranii (DC.) O. & W. (8) on Geranium maculatum L.

Uromyces vignae Barcl. (175) on Vigna sinensis (L.) Endl.

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Amaranthus blitoides Wats. Albugo bliti

Amaranthus graecizans L. Albugo bliti

Amaranthus hybridus L. Albugo bliti

Amaranthus retroflexus L. Albugo bliti

Ramularia sp.

Ambrosia artemisiifolia L. Albugo tragopogonis Entyloma compositarum

Entyloma polysporum Erysiphe cichoracearum

Plasmopara halstedii Ambrosia psilostachya DC.

Albugo tragopogonis Erysiphe cichoracearum Ambrosia trifida L.

Cercospora racemosa var. ambrosiae

Entyloma compositarum Entyloma polysporum Erysiphe cichoracearum

Plasmopara halstedii

Puccinia xanthii

Amelanchier sp.

Fabraea maculata Amelanchier canadensis (L.) Medic.

Apiosporina collinsii

Gymnosporangium corniculans

Gymnosporangium nidus-avis

Nummularia discreta Sclerotinia gregaria

Amelanchier spicata Lam.

Fabraea maculata

Gymnosporangium clavariaeforme

Amorpha canescens Pursh Erysiphe polygoni

Uropyxis amorphae Amorpha fruticosa L.

Cylindrosporium passaloroides Uropyxis amorphae

Amorpha microphylla Pursh

Uropyxis amorphae

Amphicarpa monoica (L.) Ell.

Accidium onobrychidis Cercospora monoica

Erysiphe polygoni Synchytrium decipiens

Amphicarpa pitcheri T. & G.

Erysiphe polygoni Synchytrium decipiens

Andropogon sp.

Puccinia andropogi

Andropogon furcatus Muhl.

Puccinia andropogi Puccinia ellisiana

Sorosporium provinciale

Andropogon scoparius Michx.

Puccinia andropogi Puccinia ellisiana

Andropogon tennessensis Scribn.

Puccinia andropogi Anemone spp.

Erysiphe polygoni Plasmopara pygmea

Anemone canadensis L.

Didymaria didyma

Erysiphe polygoni Plasmopara pygmea

Puccinia anemones-virginianae

Puccinia clematidis Puccinia magnusiana

Septoria anemones

Anemone caroliniana L. Plasmospora pygmea

Anemone cylindrica Gray Didymaria didyma

Phleospora anemones

Puccinia anemones-virginianae

Puccinia clematidis

Synchytrium anemones

Anemone patens var. nuttalliana Gray Puccinia suffusca

Puccinia pulsatillae

Anemone quinquefolia L.

Plasmopara pygmea

Puccinia anemones-virginianae

Puccinia clematidis

Puccinia fusca

Puccinia pruni-spinosae

Sclerotinia tuberosa

Synchytrium anemones

Urocystis anemones

Ancmone virginiana L.

Didymaria didyma

Erysiphe polygoni

Puccinia anemones-virginianae

Puccinia clematidis Septoria anemones

Urocystis anemones

Anemonella thalictroides (L.) Spach.

Erysiphe polygoni

Puccinia clematidis Anethum graveolens L.

Phoma anethi

Antirrhinum majus L.

Puccinia antirrhini Apios tuberosa Moench.

Aecidium onobrychidis

Apium graveolens L.

Bacillus sp.

Cercospora apii

Mosaic

Septoria apii

Apocynum androsaemifolium L.

Cercospora apocyni

Cylindrosporium apocyni

Phyllosticta apocuni

Aquilegia spp.

Ascochyta aquilegiae Erysiphe polygoni

Aquilegia caerulea James

Mosaic

Aquilegia canadensis L.

Mosaic

Arachis hypogaea L.

Phyllosticta sp.

Aralia nudicaulis L.

Cercospora leptosperma

Arctium minus Bernh.

Erysiphe cichoracearum

Puccinia bardanae

Arcyria denudata (L.) Sheld.

Verticillium rexianum

Arisaema dracontium L.

Uromyces caladii

Arisaema triphyllum L. Botrytis cinerea

Uromyces caladii

Armillaria mellea Fr.

Exobasidium mycetophilum

Arrhenatherum elatius (L.) Beauv.

Ustilago perennans

Artemisia biennis Willd. Albugo tragopogonis

Erysiphe cichoracearum Peronospora leptosperma

Artemisia camporum Rydb.

Puccinia universalis

Artemisia canadensis Michx. Erusiphe cichoracearum

Artemisia dracunculoides Pursh

Puccinia absinthii

Artemisia ludoviciana Nutt. Acanthostigma occidentalis Erysiphe cichoracearum Peronospora leptosperma

Puccinia absinthii

Artemisia serrata Nutt.

Erysiphe cichoracearum Peronospora leptosperma

Puccinia absinthii

Asclepias incarnata L. Septoria asclepiadicola

Septoria cryptotaenia

Uromyces howei Asclepias phytolaccoides Pursh

Cercospora clavata

Asclepias syriaca L.

Cercospora clavata

Cercospora venturioides

Macrosporium asclepiadum Mosaic

Puccinia jamesiana

Septoria cryptotaenia

Uromyces howei

Asclepias tuberosa L.

Puccinia jamesiana

Uromyces howei

Asparagus officinalis L.

Puccinia asparagi

Aster spp.

Coleosporium solidaginis Erysiphe cichoracearum

Phyllachora haydeni

Puccinia asteris

Puccinia asterum

Ramularia asteris

Ramularia filaris

Rhytisma asteris

Aster azureus Lindl.

Puccinia asteris

Aster cordifolius L. Coleosporium solidaginis

Erysiphe cichoracearum

Puccinia asteris

Puccinia asterum

Rhytisma solidaginis Septoria atropurpurea

Aster drummondii Lindl.

Coleosporium solidaginis

Puccinia asterum

Aster laevis L.

Coleosporium solidaginis Erysiphe cichoracearum

Puccinia asterum

Aster lateriflorus (L.) Britton Coleosporium solidaginis

Erysiphe cichoracearum Phyllachora haydeni

Puccinia asteris

Aster multiflorus Ait. Coleosporium solidaginis Erysiphe cichoracearum

Puccinia stipae

Aster novae-angliae L.

Puccinia asteris Ramularia asteris Ramularia macrospora

Septoria atropurpurea Aster paniculatus Lam.

Erysiphe cichoracearum Puccinia asteris Puccinia asterum

Aster prenanthoides Muhl. Coleosporium solidaginis .

Aster puniceus L.

Coleosporium solidaginis Erysiphe cichoracearum Puccinia asteris

Aster ptarmicoides T. & G. Phoma iowana

Aster sagittifolius Willd. Cladosporium astericola Coleosporium solidaginis Erysiphe cichoracearum Puccinia asterum

Aster salicifolius Lam. Coleosporium solidaginis Erysiphe cichoracearum Phyllachora haydeni

Aster tradescanti L. Puccinia asteris

Aster umbellatus Mill.

Erysiphe cichoracearum Aster undulatus L.

Puccinia asterum Astragalus canadensis L.

Erysiphe polygoni Peronospora trifoliorum Ramularia astragali

Atriplex patula L. Cercospora dubia Avena fatua L.

Puccinia coronata

Puccinia graminis Avena sativa L.

Cladosporium graminum Cladosporium herbarum Claviceps purpurea Colletotrichum graminicolum Fusarium sp. Gibberella saubinetii Helminthosporium avenae Pseudomonas coronafaciens

Pseudomonas striaefaciens

Puccinia coronata Puccinia graminis Ustilago avenae Ustilago levis

Baptisia leucantha T. & G. Marssonina baptisiae

Beckmannia erucaeformis (L.) Host. Puccinia coronata

Belamcanda chinensis DC. Didymellina iridis

Berberis canadensis L. Puccinia graminis

Berberis cerasina Schrad. Puccinia graminis

Berberis vulgaris L. Leptosphaeria berberidis Phoma berberina

Puccinia graminis Berberis vulgaris x Berberis thunbergii

Puccinia graminis Beta vulgaris L. Actinomyces scabies Albugo bliti

Cercospora beticola Corticium vagum Fusarium betae Phoma betae

Betula spp. Melanconium bicolor Septoria betulina Septoria microsperma

Betula alba var. papyrifera (Marsh.) Spach.

Melanconium bicolor Phyllactinia corylea

Bidens spp. Cercospora umbrata

Ramularia concomitans Sphaerotheca humuli

Bidens cernua L. Cercospora umbrata Plasmopara halstedii Sphaerotheca humuli

Bidens comosa (Gray) Wiegand Plasmopara halstedii

Bidens connata Muhl. Plasmopara halstedii Sphaerotheca humuli

Bidens frondosa L. Cercospora umbrata Entyloma compositarum Plasmopara halstedii Sphaerotheca humuli

Bidens involucrata (Nutt.) Britt. Sphaerotheca humuli

Bidens laevis (L.) BSP. Cercospora umbrata Plasmopara halstedii Sphaerotheca humuli

Bidens vulgata Greene Plasmopara halstedii

Sphaerotheca humuli Blephila hirsuta (Pursh) Torr. Puccinia menthae

Boltonia asteroides (L.) L'Her.

Puccinia asterum

Septoria erigerontis var. boltonia

Boutcloua curtipendula (Michx.) Torr.

Phyllachora graminis

Puccinia jamesiana Puccinia vexans

Brassica arvensis L.
Albugo candida

Peronospora parasitica

Brassica campestris L.

Peronospora parasitica

Pseudomonas campestris

Brassica juncea L.

Peronospora parasitica Brassica nigra (L.) Koch.

Albugo candida Alternaria brassicae Alternaria herculea Erysiphe polygoni

Peronospora parasitica

Brassica oleracea L. var. capitata

Alternaria brassicae
Bacillus carotovorus
Botrytis cinerea
Fusarium conglutinans
Peronospora parasitica
Phoma lingam
Plasmodiophora brassicae
Pseudomonas campestris

Brassica rapa L.

Erysiphe polygoni

Brauneria purpurea (DC.) Britton

Cercospora tabacina

Bromus brevi-aristatus (Hooker) Buckl.

Ustilago bromivora

Bromus ciliatus L.

Puccinia clematidis

Urocystis agropyri

Ustilago bromivora

Bromus inermis Leyss.

Claviceps purpurea

Pseudomonas coronafaciens var. atropurpurea

Ustilago macrospora

Bromus purgans L.
Cladosporium graminum

Colletotrichum graminicolum Puccinia clematidis

Bromus secalinus L.
Puccinia graminis
Septoria bromi

Cacalia atriplicifolia L. Septoria cacaliae Cacalia reformis Muhl.

Septoria cacaliae Calamagrostis canadensis (Michx.)

Beauv.
Claviceps microcephala
Claviceps purpurea
Puccinia coronata
Calendula officinalis L.

Mosaic

Callistephus chinensis Nees. Coleosporium solidaginis

Fusarium spp.

Fusarium conglutinans var. callistephi Yellows

Caloptenus differentialis Thomas Empusa grylli

Caltha palustris L.

Puccinia calthae

Puccinia calthaecola

Calveanthus floridus L.

Macrosporium calycanthi

Campanula americana L.

Aecidium campanulastri
Septoria campanulae

Canna spp.

Pseudomonas cannae Cannabis sativa L.

Septoria cannabis

Capsella bursa-pastoris L.

Albugo candida
Corticium vagum
Cylindrosporium capsellae
Peronospora parasitica

Capsicum frutescens var. grossum Bailey
Alternaria sp.

Fusarium sp.
Mosaic

Caragana arborescens Lam. Sphaeropsis sp.

Carex sp.

trex sp.
Cladosporium herbarum
Puccinia asterum
Puccinia grossulariae
Puccinia hieraciata
Puccinia urticae
Schizonella melanogramma
Thecaphora aterrima

Carex adusta Boott.

Puccinia asterum

Thecaphora aterrima

Carex aquatilis Wahlenb.

Puccinia urticae

Carex atheiodes Spreng.

Puccinia urticae

Carex brevior (Dewey) Mackenzie Puccinia asterum

Carex cephalophora Muhl.

Puccinia asterum

Carex crinita Lam.

Puccinia grossulariae
Carex emoryi Dewey

Puccinia urticae Carex foenea Willd.

Puccinia asterum Carex grisea Wahl.

Puccinia hieraciata Carex intumescens Rudge Uromyces perigynius

Carex laxiflora var. blanda Dewey Puccinia grossulariae

Carex mirabilis Dewey

Cercospora caricina

Carex normalis MacKenzie
Puccinia asterum

Carex pennsylvanica Lam.

Cintractia caricis Puccinia asterum

Schizonella melanogramma

Carex praegracilis W. Boott

Puccinia asterum

Carex pubescens Muhl.

Puccinia graminis

Uromyces minutus

Carex riparia W. Curtiss Puccinia grossulariae

Puccinia urticae

Carex siccata Dewey
Puccinia hieraciata

Carex sparganioides Muhl.

Puccinia asterum

Puccinia grossulariae

Carex sprengelii Dewey
Puccinia peckii
Puccinia phrymae

Carex stipata Muhl.

Puccinia asterum

Puccinia grindeliae

Puccinia grossulariae

Carex straminea Schk.

Puccinia asterum

Carex stricta Lam.
Puccinia asterum

Puccinia grossulariae Puccinia urticae

Carex substricta (Kükenth) MacKenzie Puccinia grossulariae

Carex tribuloides Schk.

Puccinia asterum

Carex trichocarpa Muhl.

Puccinia peckii

Carex vulpinoidea Michx.

Puccinia asterum Carpinus caroliniana Walt.

Microsphacra alni Phyllactinia corylea

Carya sp.

Gnomonia leptostyla Carya laciniosa (Michx. f.) Loud. Microstroma juglandis

Carya ovata (Mill.) Koch.
Gnomonia caryac

Microstroma juglandis

Castalia sp.

Entyloma nymphaeae

Castalia tuberosa (Paine) Greene Entyloma nymphaeae

Castanea sp.

Endothia parasitica Fusicoccum castancum

Castanea dentata (Marsh.) Bork. Endothia parasitica

Castilleja coccinea (L.) Spreng.

Puccinia andropogi

Castilleja sessiliflora Pursh Puccinia andropogi Catalpa sp.

Cercospora catalpae

Catalpa bignonioides Walt. var. nana Microsphaera alni

Catalpa speciosa Warder Cercospora catalpae Microsphaera alni

Caulophyllum thalictroides (L.) Michx.

Cercospora caulophylli Ceanothus americanum L. Microsphaera alni

Celastrus scandens L.
Cercospora melanochaeta
Phyllactinia corylea

Ramularia celastri Celtis occidentalis L.

Cercospora spegazzinii Mosaic

Mosaic Septoria celtis-galtae Sphaerotheca phytoptophila

Uncinula parvula Cenchrus carolinianus Wahl. Sorosporium syntherismae

Centaurea sp.

Plasmopara halstedii Cerastium nutans Casp. Peronospora alsinearum

Cercis canadensis L.
Cercosporella chionea

Chenopodium spp.

Cercospora dubia

Peronospora effusa

Chenopodium album L.
Cercospora dubia
Peronospora chenopodii
Peronospora effusa
Phoma longissima

Chenopodium album var. viride (L.) Moq. Peronospora chenopodii

Chenopodium hybridum L. Cercospora dubia Peronospora chenopodii Peronospora effusa

Chrysanthemum spp.
Puccinia chrysanthemi
Septoria chrysanthemella

Chrysanthemum carinatum L.

Erysiphe cichoracearum

Chrysanthemum maximum Res

Chrysanthemum maximum Ram. Septoria chrysanthemella

Cicuta maculata L.

Uromyces scirpi
Cinna arundinacea L.

Erysiphe graminis
Puccinia coronata

Circaea lutetiana L.

Puccinia circaeae

Cirsium altissimum (L.) Spreng.
Acanthostigma occidentalis
Erysiphe cichoracearum
Puccinia cirsii
Septoria cirsii

Cirsium arvense (L.) Scop.

Albugo tragopogonis
Cirsium discolor Muhl.

Acanthostigma occidentalis
Erysiphe cichoracearum

Puccinia cirsii Septoria cirsii

Cirsium iowense (Pammel) Fernald Puccinia cirsii Sentoria cirsii

Cirsium lanceolata (L.) Hill Puccinia cnici

Citrullus vulgaris L.
Colletotrichum lagenarium
Fusarium niveum
Masaje

Claytonia virginiana L. Puccinia claytoniata

Clematis spp.

Puccinia clematidis

Clematis pitcheri Torr. & Gray Septoria elematidis Clematis viorna L.

Puccinia clematidis
Clematis virginiana L.

Cercospora squalidula Erysiphe polygoni Puccinia elematidis Septoria elematidis Cleome serrulata Pursh

Heterosporium hybridum
Comandra pallida A. DC.
Cronartium pyriforme

Puccinia andropogi

Comandra umbellata (L.) Nutt.
Cronartium pyriforme
Puccinia andropogi

Convolvulus arvense L. Septoria convolvuli

Convolvulus sepium L.
Puccinia convolvuli
Septoria convolvuli

Cornus spp.
Septoria cornicola

Cornus alba var. siberica Cy.
Septoria cornicola

Cornus alternifolia L. f.

Microsphaera alni
Septoria cornicola

Cornus amomum Mill.

Phyllosticta globifera
Septoria cornicola

Cornus asperfolia Michx. Septoria cornicola

Cornus florida L.

Phyllactinia corylea

Cornus paniculata L'Her.

Dimerosporium pulchrum

Microsphaera alni

Septoria cornicola

Cornus sanguinea L. Phyllactinia corylea

Cornus stolonifera Michx.

Phyllactinia corylea

Septoria cornicola

Cornus stolonifera var. aurea (cult.) Hort.

Septoria cornicola

Cornus stolonifera var. lutea (cult.)

Septoria cornicola Cornus stricta Lam.

Phyllactinia corylea

Corylus americana Walt.
Gloeosporium coryli
Microsphaera alni
Phyllactinia corylea
Phyllosticta coryli

Corylus rostrata Ait.

Microsphaera alni

Septoria coryli Cosmos sp.

Phomopsis stewartii
Cosmos bipinnatus Cav.
Erysiphe cichoracearum

Phomopsis stewartii
Cotoneaster sp.

Fabraea maculata Crataegus spp.

Cladosporium sp. Gymnosporangium globosum Gymnosporangium juniperi-virginianae Phullactinia corulea

Podosphaera oxyacanthae Crataegus coccinea L.

Podosphaera oxyacanthae Crataegus margaretta Ashe Gymnosporangium globosum

Sclerotinia johnsoni Crataegus megeeae Ashe Gymnosporangium globosum

Crataegus mollis (T. & G.) Scheele Cladosporium carpophilum Fabraea maculata

Gymnosporangium globosum Gymnosporangium juniperi-virginianae

Podosphaera oxyacanthae Sclerotinia johnsoni Crataegus monogyna Jacq.

Bacillus amylovorus Gymnosporangium germinale Physalospora malorum

Crataegus oxyacantha L.
Bacillus amylovorus
Fabraea maculata
Phyllosticta rubra

Crataegus pertomentosa Ashe Gymnosporangium globosum

Crataegus punctata Jacq.
Gymnosporangium globosum
Podosphaera oxyacanthae

Crataegus rotundifolia Moench.

Cymnosporangium globosum

Crataegus tomentosa L.
Gymnosporangium globosum

460 Phyllactinia corylea Podosphaera oxyacanthae Cryptogramma stelleri (Gmel.) Prantl Hyalopsora cheilanthus Cryptotaenia canadensis (L.) DC. Puccinia cryptotaeniae Puccinia microica Septoria cryptotaeniae Cucumis melo L. Bacillus tracheiphilus Colletotrichum lagenarium Mosaic Pseudopersonospora cubensis Cucumis sativus L. Bacillus tracheiphilus Erysiphe cichoracearum Mosaic Pseudomonas lachrymans Pseudoperonospora cubensis Cucurbita maxima Duchesne Bacillus tracheiphilus Cercospora sp. Erysiphe cichoracearum Cucurbita pepo L. Erysiphe cichoracearum Macrosporium cucumerinum Cucurbita pepo var. condensa L. Mosaic Cydonia oblonga Mill. Fabraea maculata Cyperus erythrorhizos Muhl. Puccinia canaliculata Cyperus esculentus L. Puccinia canaliculata Cyperus filiculmis Vahl. Puccinia cyperi Cyperus schweinitzii Torr. Puccinia cyperi Cyperus strigosus L. Puccinia canaliculata Cypripedium hirsutum Mill. Puccinia cypripedii Cypripedium parviflorum var. pubescens (Willd.) Knight Puccinia cypripedii Cystopteris fragilis Bernh. Hyalopsora polypodiiDactylis glomerata L. Puccinia coronata Puccinia graminis Scolecotrichum graminis Dahlia sp. Erysiphe polygoni Dahlia pinnata Cav.

Erysiphe cichoracearum

Datura stramonium L. Alternaria crassa

Alternaria crassa

Bacillus carotovorus

Datura tatula L.

Daucus carota L.

Danthonia spicata (L.) Beauv. Balansia hypoxylon

Cercospora apii var. carotae

Delphinium sp. Pseudomonas delphinii Sclerotium delphinii Delphinium belladonna Hort. Pseudomonas delphinii Dentaria laciniata Muhl. Peronospora parasitica Septoria sisymbrii Desmodium sp. (Meibomia sp.) Microsphaera diffusa Ramularia desmodii Desmodium canadense (L.) DC. Microsphaera diffusa Parodiella grammodes Phyllactinia corylea Phyllosticta desmodii Ramularia desmodii Uromyces hedysari-paniculati Desmodium dillenii Darl. Uromyces hedysari-paniculati Desmodium grandiflorum (Walt.) DC. Phyllactinia corylea Desmodium nudiflorum (L.) DC. Cercospora desmodii Desmodium sessilifolium Torr. Uromyces hedysari-paniculati Deutzia gracilis Sieb. & Zucc. Cercospora deutziae Deutzia scabra candidissima Hort. Phyllosticta deutziae Dianthus spp. Septoria dianthi Dianthus caryophyllus L. Uromyces caryophyllus Dianthus plumarius L. Volutella dianthi Dicentra cucullaria L. Cerotelium dicentrae Diervilla lonicera Mill. Septoria diervillae Digitaria humifusa Pers. Ustilago rabenhorstiana Digitaria sanguinalis (L.) Scop. Piricularia grisea Sorosporium syntherismae Ustilago rabenhorstiana Dioscorea villosa L. Cercospora dioscoreae Direa palustris L. Aecidium hydnoideum Draba caroliniana Walt. Peronospora parasitica Echinochloa crus-galli (L.) Beauv. Cercospora fusimaculans Puccinia graminis Tolyposporium bullatum Ustilago sphaerogena Echinocystis lobata (Michx.) T. & G. Cercospora echinocystidis Plasmopara australis Pseudoperonospora cubensis Septoria sicyi Elaeagnus angustifolia L.

Septoria argyrea Tubercularia vulgaris Elaphomyces variegatus Vitt. Cordyceps ophioglossoides

Eleocharis intermedia (Muhl.) Schul. Puccinia eleocharidis

Eleocharis palustris (L.) R. & S. Puccinia eleocharidis

Uromyces eleocharidis

Ellisia nyctelea L. Peronospora hydrophylli Puccinia apocrypta Puccinia hydrophylli

Elymus sp.

Urocystis agropyri

Elymus canadensis L. Claviceps purpurea Erysiphe graminis Phyllachora graminis Puccinia clematidis Puccinia graminis Puccinia impatientis Puccinia montanensis Scolecotrichum graminis Urocystis agropyri

Ustilago hypodytes Elymus macounii Vasey

Puccinia graminis Elymus robustus Scribn. & Sm. Cladosporium graminum Claviceps purpurea Phyllachora graminis Puccinia graminis Puccinia impatientis Puccinia robustus

Septoria elymi Urocystis agropyri Elymus striatus Willd. Claviceps purpurea Puccinia striatus

Puccinia impatientis Puccinia montanensis Elymus virginicus L. Cladosporium graminum

Claviceps purpurea Epichloe typhina Phyllachora graminis Puccinia clematidis Puccinia montanensis

Ustilago striaeformis Epilobium coloratum Muhl. Pucciniastrum pustulatum Sphacrotheca humuli

Equisetum sp. Septoria equiseti

Equisetum arvense L. Cladosporium herbarum

Eragrostis megastachya (Koeler) Link Ustilago spermophora Ercehtites hieracifolia (L.) Raf.

Sphaerotheca humuli

Erigeron sp. Cercosporella cana Plasmopara halstedii Puccinia asterum

Erigeron annuus (L.) Pers. Cercosporella cana Puccinia asterum

Septoria erigerontis Erigeron canadensis L.

Cercosporella cana Puccinia asterum Septoria erigerontis Sphaerotheca humuli

Erigeron philadelphicus L. Puccinia asterum Septoria erigerontis Sphaerotheca humuli

Erigeron ramosus (Walt.) BSP. Puccinia asterum Septoria erigerontis var. boltonia Septoria erigerontis

Eriophorum angustifolium Roth. Puccinia eriophori

Eryngium yuccifolium Michx. Cylindrosporium eryngii

Entyloma eryngii Erysimum cheiranthoides L. Erysiphe polygoni

Erysimum parviflora Nutt. Peronospora parasitica

Erysiphe cichoracearum DC. Cicinnobolus cesati

Erysiphe polygoni DC. Cicinnobolus cesati

Euchlaena mexicana Schrad. Sclerospora graminicola Ustilago zeae

Eupatorium maculatum L. Puccinia eleocharidis

Eupatorium perfoliatum L. Puccinia eleocharidis

Eupatorium purpureum L. Erysiphe cichoracearum Plasmopara halstedii Puccinia eleocharidis

Eupatorium urticaefolium Reich. Entyloma compositarum Erysiphe cichoracearum Puccinia tenuis

Septoria eupatoriae

Euphorbia commutatus Engelm. Accidium tithymali

Euphorbia corollata L. Fusicladium fasciculatum Microsphaera euphorbiae Puccinia pammelii

Euphorbia cyparissias L. Melampsora euphorbiae Euphorbia dentata Michx.

Uromyces procminens Euphorbia glyptosperma Engelm.

Peronospora euphorbiae Euphorbia heterophylla L.

Uromyces proeminens Euphorbia humistrata Engelm. Uromyces proeminens

Euphorbia maculata L. Peronospora chamaesycis Peronospora euphorbiae Uromyces proeminens Euphorbia marginata Pursh Microsphaera euphorbiae Uromyces proeminens

Euphorbia polygonifolia L.

Uromyces proeminens Euphorbia preslii Guss.

Mosaic

Peronospora euphorbiae Uromyces proeminens

Euphorbia serpyllifolia Pers.
Peronospora euphorbiae
Uromyces proeminens

Evonymus americanus L.

Oidium sp.

Evonymus atropurpureus Jacq.

Cercospora evonymi Marssonina thomasina Microsphaera alni Ramularia evonymi

Exidia glandulosa Fr. Hypocrea citrina

Fagopyrum esculentum L. Alternaria sp.

Festuca sp.

Helminthosporium spp.

Festuca elatior L.

Helminthosporium sativum
Puccinia coronata

Puccinia graminis

Festuca nutans Willd.

Ustilago striaeformis

Forsythia sp.

Alternaria forsythiae

Fragaria spp.
Mycosphaerella fragariae
Peronospora fragariae
Pezizella lythri
Rhizopus nigricans

Fragaria chiloensis Duchesne Mycosphaerella fragariae

Fragaria vesca L.

Mycosphaerella fragariae Fragaria virginiana Duchesne Mycosphaerella fragariae

Fraxinus spp.

Cercospora superflua Cylindrosporium fraxini Gloeosporium aridum Phyllactinia corylea

Fraxinus americana L.
Cylindrosporium fraxini
Gloeosporium aridum
Phyllactinia corylea

Puccinia fraxinata Fraxinus pennsylvanica Marsh.

Puccinia fraxinata
Fraxinum pennsylvanica var. lanceolata
(Borkh.) Sarg.

Cylindrosporium fraxini Gloeosporium aridum Phyllactinia corylea Puccinia fraxinata Uncinula circinata

Gaillardia spp.
Septoria gaillardiae

Galium sp.

Peronospora calotheca

Galium aparine L.
Cercospora galii
Peronospora calotheca
Puccinia ambigua

Galium asprellum Michx.

Puccinia punctata

Galium boreale L.

Melasmia galii
Peronospora calotheca
Puccinia galiorum
Puccinia rubefaciens

Galium circaezans Michx.

Erysiphe cichoracearum

Galium concinnum T. & G.

Puccinia galiorum

Puccinia punctata

Galium tinctorium L. Puccinia punctata

Galium trifidum L.

Puccinia punctata
Galium triflorum Michx.

Puccinia troglodytes
Gaura biennis L.

Peronospora arthuri Uromyces plumbarius Gentiana andrewsii Griseb.

Phyllosticta gentianicola Gentiana flavida Gray

Phyllosticta gentianicola Gentiana puberula Michx. Puccinia gentianae

Gentiana quinquefolia L.
Puccinia gentianae

Gentiana quinquefolia var. occidentalis (Gray) Hitchc.

Uromyces gentianae

Geranium spp.

Botrytis cinerea

Puccinia polygoni-amphibii Geranium carolinianum L.

Plasmopara geranii Geranium maculatum I

Geranium maculatum L.
Cercospora geranii
Erysiphe polygoni
Plasmopara geranii
Puccinia polygoniamal

Puccinia polygoni-amphibii

Gerardia tenuifolia Vahl.
Sphaerotheca humuli

Geum canadense Jacq.

Peronospora potentillae
Sphaerotheca humuli

Gladiolus sp.

Fusarium oxysporum var. gladioli Penicillium gladioli Pseudomonas marginata Sclerotium gladioli Gleditsia triacanthos L. Cercospora olivacea

Glyceria sp.

Ustilago longissima

Glyceria fluitans (L.) R. Br.

Claviceps purpurea Glyceria grandis S. Wats. Puccinia clematidis Ustilago arthurii Ustilago longissima Glycyrrhiza lepidota Nutt.

Uromuces glycyrrhizae

Gonobolus laevis Michx. Plasmopara gonoboli

Grass

Hadrotrichum lineare

Grindelia squarrosa (Pursh) Dunal. Erysiphe cichoracearum Grossularia reclinata (L.) Mill.

Puccinia grossulariae Gymnocladus dioica (L.) Koch.

Cercospora gymnocladi Helenium autumnale L.

Erysiphe cichoracearum Septoria helenii

Helenium hoopesii Gray Septoria helenii

Helianthus sp.

Erysiphe cichoracearum Plasmopara halstedii

Helianthus annuus L. Erysiphe cichoracearum Plasmopara halstedii Puccinia helianthi-mollis Sclerotinia libertiana

Helianthus debilis Nutt. Erysiphe cichoracearum

Helianthus doronicoides Lam.

Cercospora helianthi Erysiphe cichoracearum Plasmopara halstedii Puccinia helianthi-mollis Helianthus giganteus L.

Erysiphe cichoracearum Helianthus grosse-serratus Martens

Erysiphe cichoracearum Plasmopara halstedii Puccinia helianthi-mollis Septoria helianthi

Helianthus laetiflorus Pers. Erysiphe cichoracearum Puccinia helianthi-mollis

Helianthus maximiliani Schrad.

Plasmopara halstedii Puccinia helianthi-mollis Helianthus mollis Lam.

Puccinia helianthi-mollis Helianthus occidentalis Ridd.

Puccinia helianthi-mollis Uromyces junci

Helianthus petiolaris Nutt. Erysiphe cichoracearum Puccinia helianthi-mollis

Helianthus scaberrimus Ell. Puccinia helianthi-mollis Helianthus strumosus L. Erysiphe cichoracearum

Puccinia helianthi-mollis Septoria helianthi

Helianthus tracheliifolius Mill. Puccinia helianthi-mollis

Helianthus tuberosus L. Erysiphe cichoracearum Plasmopara halstedii Puccinia helianthi-mollis Septoria helianthi

Heliopsis scabra Dunal Erysiphe cichoracearum Erysiphe taurica

Mosaic

Puccinia batesiana Hepatica acutiloba DC.

 $\hat{D}iscosia$ artocreas Plasmopara pygmea Puccinia pruni-spinosae Urocystis anemones

Heracleum lanatum L. Ramularia heraclei

Heuchera hispida Pursh Cercospora heucheri Hieracium canadense Michx.

Puccinia hieracii Holcus halepensis L.

Pscudomonas holci Holcus sorghum L. Pseudomonas andropogoni Pseudomonas holci

Puccinia sorghi Sclerospora graminicola Sorosporium reilianum Sphacclotheca sorghi

Holcus sorghum var. technicus Bailey Fusarium sp.

Holcus sudanensis Bailey Pseudomonas holci Sphacelotheca sorghi

Hordeum spp. Ustilago hordei Hordeum jubatum L.

Erysiphe graminis Puccinia clematidis Puccinia graminis Septoria passerinii

Hordeum pammelii Scribn. Puccinia graminis

Hordeum pusillum L. Uromyces hordei

Hordeum vulgare L. Cladosporium herbarum Claviceps purpurea Colletotrichum graminicolum Gibberella saubinetii Helminthosporium gramineum

Helminthosporium sativum

Pseudomonas translucens

Puccinia graminis

Puccinia simplex
Pyrenophora teres
Ehynchosporium secalis
Scolecotrichum graminis
Septoria passerinii
Ustilago hordei
Ustilago nuda

Houstonia patens Ell.

Peronospora seymourii

Humulus sp.

Phyllosticta humuli

Humulus lupulus L.

Cylindrosporium humuli

Phyllosticta decidua

Phullosticta humuli

Hydrophyllum virginianum L.
Erysiphe cichoracearum
Peronospora hydrophylli
Puccinia apocrypta

Puccinia apocrypta Puccinia hydrophylli

Hypericum ascyron L.
Uromyces hyperici-frondosi

Hypericum mutilum L.

Septoria sphaerelloides
Uromyces hyperici-frondosi
Hypericum virginicum L.

Uromyces hyperici-frondosi

Hystrix patula Moench.
Claviceps purpurea
Phyllachora graminis
Puccinia montanensis

Impatiens spp.
Plasmopara obducens

Puccinia impatientis Puccinia nolitangeris

Impatiens biflora Walt.

Mycosphaerella impatientis

Plasmopara obducens

Puccinia impatientis Puccinia nolitangeris Ramularia impatientis

Ramularia impatientis Impatiens pallida Nutt. Mycosphaerella impatientis

Plasmopara obducens Puccinia impatientis Puccinia nolitangeris Ramularia impatientis

Septoria nolitangeris Ipomoea batatas Lam.

Albugo ipomoeae-panduranae Ceratostomella fimbriata Fusarium batatatis Fusarium hyperoxysporum Fusarium orthocaras

Fusarium oxysporum Moniliochaetes infuscans

Mosaic Phyllosticta batatas Plenodomus destruens Rhizoctonia bataticola Rhizopus nigricans Septoria bataticola Ipomoea hederacea Jacq.
Albugo ipomoeae-panduranae

Iris spp.

Cylindrosporium iridis Didymellina iridis Leptosphaeria heterospora

Iris germanica L.

Didymellina iridis
Iris versicolor L.

Cylindrosporium iridis Puccinia iridis

Puccinia majanthae Isopyrum biternatum (Raf.) T. & G.

Puccinia clematidis Iva xanthiifolia Nutt. Basidiophora kellermanii Physalospora arthuriana Puccinia xanthiifoliae

Juglans cinerea L.
Gnomonia leptosyla
Melanconis juglandis
Microstroma juglandis

Juglans nigra L,
Gnomonia leptostyla
Microsphaera alni
Microstroma juglandis
Juglans regia L.

Juglans regia L.

Microsphaera alni

Vi

Juncus interior Wiegand
Phyllachora junci
Uromyces silphii
Juncus tenuis Willd.

Juncus tenuis Willd Cintractia junci Uromyces silphii

Juniperus spp.

Lophodermium juniperinum Juniperus communis L.

Exosporium juniperinum Gymnosporangium clavariaeforme Lophodermium juniperinum

Juniperus virginiana L.

Gymnosporangium germinale Gymnosporangium globosum

Gymnosporangium juniperi-virginianae Gymnosporangium nidus-avis

Phomopsis juniperovora

Poria purpurea Kerria japonica DC.

Coccomyces kerriae Koeleria cristata Pers.

Claviceps purpurea

Krigia amplexicaulis Nutt.

Puccinia hieraciata

Kuhnia eupatoroides L. Puccinia kuhniae

Lactarius spp.

Hypomyces lactifluorum

Lactuca sp.

Bremia lactucae

Lactuca canadensis L.

Bremia lactucae
Puccinia hieraciata
Septoria lactucicola
Lactuca hirsuta Muhl.
Septoria lactucicola
Lactuca ludoviciana Nutt.
Bremia lactucae
Puccinia hieraciata

Lactuca pulchella (Pursh) DC.
Puccinia hieraciata

Lactuca sagittifolia Ell.

Bremia lactucae

Lactuca sativa L.
Botrytis cinerea
Bremia lactucae
Corticium vagum
Sclerotinia libertiana

Lactuca scariola DC. Mosaic

Septoria lactucicola Lactuca scariola var. integrata Gren. & Godr.

Bremia lactucae

Lactuca spicata (Lam.) Hitchc.

Bremia lactucae

Laportea canadensis (L.) Gaud. Peronospora urticae

Septoria urticae
Lappula virginiana (L.) Greene
Erysiphe cichoracearum
Peronosnora echinosnermi

Peronospora echinospermi Lathyrus myrtifolius Muhl. Uromyces fabae

Lathyrus odoratus L. *Microsphera alni*

Lathyrus palustris L. Microsphaera alni

Lathyrus venosus Muhl. Gloeosporium davisii

Uromyces fabae Ledum groenlandicum Oeder.

Melampsora ledicola Leersia virginica Willd. Tilletia corona

Uromyces halstedii Lepachys pinnata T. & G. Entyloma compositarum Plasmopara halstedii

Lepidium sp.

Peronospora parasitica

Lepidium apetalum Willd.

Albugo candida

Peronospora lepidii

Peronospora parasitica

Lepidium draba L.
Albugo candida

Lepidium virginicum L.

Albugo candida

Peronospora parasitica

Lespedeza capitata Michx.

Phyllachora lespedezae

Uromyces lespedezae-procumbentis

Lespedeza leptostachya Engelm.
Uromyces lespedezae-procumbentis

Liatris sp.

Septoria liatridis
Lilium superbum L.

Uromyces lilii Limonium latifolium Kuntze Ascochyta plumbaginicola

Ascochyta plumbagini Linum sulcatum Ridd. Melampsora lini

Linum usitatissimum L.
Fusarium lini

Melampsora lini Linum virginianum L.

Melampsora lini Lippia lanceolata Michx. Cercospora lippae

Liriodendron tulipifera L.

Myxosporium tulipiferiae

Lobelia spicata Lam.

Puccinia lobeliae

Septoria lobeliae

Lobelia siphilitica L.
Cercospora effusa
Puccinia lobeliae
Septoria lobeliae

Lonicera spp.

Cercospora antipus

Microsphaera alni

Puccinia periolumen

Puccinia periclymeni Lonicera dioica L. Microsphaera alni

Lonicera flava Sims
Cercospora antipus
Microsphaera alni
Puccinia periclymeni

Lonicera sempervirens L. Cercospora antipus

Lonicera sullivantii Gray Cercospora antipus Microsphaera alni Puccinia periclymeni

Lonicera tatarica L.

Microsphaera alni

Lonicera tatarica var. alba Hort.

Microsphaera alni

Lonicera tatarica var. rosea Hort. Microsphaera alni

Lonicera tatarica var. siberica Hort.

Microsphaera alni

Ludvigia polycarpa S. & S.

Phyllosticta sp.
Puccinia jussiaeae

Luzula intermedia (Thuill.) A. Nels. Puccinia obscura

Lychnis coronaria Desr.

Phyllosticta lychnidis
Lycium barbarum L.

Lycium barbarum L. Cercospora lycii

Lycium halimifolium Mill.

Alternaria tenuis

Cercospora lycii Puccinia tumidipes 466 Lycospersicon esculentum Mill. Alternaria solani Cladosporium fulvum Fusarium lycopersici Macrosporium tomato Mosaic Phoma destructiva Pseudomonas vesicatoria Septoria lycopersici Streak Lycopus americana Muhl. Puccinia angustata Lycopus rubellus Moench. Phyllosticta decidua Malva rotundifolia L. Cercospora althaeina Septoria malvicola Martynia louisiana Mill. Mosaic Medicago lupulina L. Macrosporium sp. Peronospora trifoliorum Medicago sativa L. Ascochyta imperfecta Bacterium insidiosum Colletotrichum trifolii Macrosporium sp. Peronospora trifoliorum Pleosphaerulina briosiana Pseudomonas medicaginis Pseudopeziza medicaginis Pyrenopeziza medicaginis Rhizoctonia crocorum Uromyces medicaginis White spot (non-parasitic) Yellows Melampsora bigelowii Thüm. Darluca filum Fusarium herbarum Melampsora humboltiana Speg. Darluca filum Melampsora medusae Thüm. Darluca filum Fusarium herbarum Melilotus alba Desr. Cercospora davisii Corticium vagum Mycosphaerella lethalis Melilotus officinalis L. Cercospora davisii Corticium vagum Mycosphaerella lethalis Peronospora trifoliorum Menispermum canadense L. Cercospora menispermi Entyloma menispermi Microsphaera alni Phyllosticta abortiva Mentha sp.

Puccinia menthae Mentha arvensis L.

Erysiphe galeopsidis

Phyllosticta decidua Puccinia menthae Mertensia virginica DC. Entyloma serotinum Mimulus ringens L. Septoria mimuli Mitella diphylla L. Puccinia heucherae Momordica balsamina L. Pseudoperonospora cubensis Monarda sp. Synchytrium holwayii Monarda mollis L. Puccinia menthae Synchytrium holwayii Morus spp. Cercospora moricola Gibberella moricola Pseudomonas mori Morus alba L. Cercospora moricola Phleospora maculans Morus alba tartarica Loudon Pseudomonas mori Morus rubra L. Cercospora moricola Uncinula geniculata Mucor mucedo L. Syncephalis cornu Muhlenbergia spp. Epichloe typhina Phyllachora vulgata Muhlenbergia cuspidata (Torr.) Rydb. Puccinia graminis Puccinia hibisciata Muhlenbergia mexicana (L.) Trin. Phyllachora graminis Puccinia graminis Puccinia hibisciata Scolecotrichum graminis Muhlenbergia schreberi Gmel. Phyllachora vulgata Puccinia hibisciata Muhlenbergia sobolifera (Muhl.) Trin. Phyllachora vulgata Musea spp. Empusa muscae Napaea dioica L. Puccinia hibisciata Narcissus sp. Botrytis sp. Fusarium sp. Nepeta cataria L. Mosaic Nicotiana tabacum L. Macrosporium longipes Mosaic Nothocalais cuspidata (Pursh) Greene Puccinia hieracii Notholeus lanatus (L.) Nash Puccinia graminis

Mentha arvensis var. canadensis (L.)

Briquet

Nymphaea advena Ait. Phyllosticta faticens Oenothera biennis L. Erysiphe polygoni Peronospora arthuri Puccinia peckii Sentoria oenotherae Sunchutrium fulgens Uromuces plumbarius Ocnothera lamarkiana Ser. Sentoria oenotherae

Oenothera serrulata Nutt.

Puccinia peckii

Oidium sp.

Cicinnobolus cesati

Osmorhiza claytoni (Michx.) Clarke Puccinia pimpinellae

Osmorhiza longistyles (Torr.) DC. Puccinia pimpinellae

Ostrva sp.

Phyllactinia corylea

Ostrya virginiana (Mill.) K. Koch. Microsphaera alni Phyllactinia corylea

Septoria ostruae Taphrina virginica

Oxalis corniculata L. Puccinia sorahi

Oxalis stricta L.

Microsphaera russcllii Puccinia sorghi

Ustilago oxalidis Oxalis violacea L.

Puccinia sorahi Oxybaphus nyctagineus (Michx.) Sweet Ascochyta oxybaphi

Cercospora oxubaphi Oxytropis lamberti Pursh

Erysiphe polygoni

Paeonia spp.

Botrutis paeoniae Cercospora variicolor Mosaic

Paconia officinalis L. Cercospora variicolor Cladosporium paeoniac

Panax quinquefolium L. Alternaria panax Papery leaf spot

Phytophthora cactorum

Panicum sp.

Colletotrichum graminicolum Panicum agrostoides Muhl.

Phyllachora puncta Panicum capillare L.

Puccinia emaculata Sorosporium syntherismae Ustilago rabenhorstiana

Panicum dichotomiflorum Michx. . Sorosporium syntherismae Tolyposporium bullatum Ustilago pustulata

Ustilago rabenhorstiana

Panicum dichotomum L. Phyllachora puncta Panieum latifolium L.

Phyllachora puncta

Panicum miliaceum L. Schizonella melanogramma

Sclerospora graminicola

Panicum scoparium Lam. Phyllachora puncta

Panicum scribnerianum Nash

Phyllachora puncta Panicum virgatum L.

Puccinia pammelii Septoria sigmoidea Tilletia maclagani Uromyces graminicola

Papaver sp.

Entyloma fuscum

Parietaria pennsylvanica Muhl. Erysiphe cichoracearum Septoria parietariae

Parthenium integrifolium L. Albugo tragopogonis

Pastinaca sativa L.

Cercospora apii var. pastinacae Pennisetum glaucum (L.) R. Br.

Pseudomonas holci Penstemon gracilis Nutt.

Puccinia andropogi Penstemon grandiflorus Nutt.

Puccinia andropogi Penthorum sedoides L.

Cercospora sedoides Petalostemum purpureum (Vent.) Rydb.

Uropyxis petalostemonis Petunia violacea Lindl.

Mosaic

Phalaris arundinacea L. Puccinia majanthae

Phaseolus diversifolius Pers. Uromyces appendiculatus

Phaseolus lunatus L.

Colletotrichum lindemuthianum

Phaseolus lunatus var. macrocarpus Benth.

Erysiphe polygoni Phaseolus vulgaris L.

Colletotrichum lindemuthianum

Erysiphe polygoni Fusarium martii var. phaseoli

Pseudomonas phaseoli

Uromyces appendiculatus

Phleum pratense L. Claviceps purpurea Entyloma crastophilum

Epichloe typhina Puccinia clematidis Puccinia coronata Puccinia graminis Puccinia impatientis

Scolecotrichum graminis Sporotrichum poae

Ustilago striaeformis

Phlox spp. Cercospora omphakodes Erysiphe cichoracearum Leptosphaeria phlogis Puccinia plumbaria Septoria phlogis

Uromyces polemonii

Phlox divaricata L. Cercospora omphakodes Erysiphe cichoracearum Peronospora phlogina Puccinia plumbaria Septoria divaricatae

Phlox divaricata L. var. laphamii Wood Septoria divaricatae

Uromyces polemonii Phlox drummondii Hook. Erysiphe cichoracearum

Phlox glaberrima var. suffructicosa Gray Cercospora omphakodes

Phlox paniculata L. Puccinia plumbaria Septoria phlogis Uromyces polemonii

Phlox pilosa L. Puccinia plumbaria Uromyces polemonii

Phragmites communis Trin. Claviceps microcephala Neovossia iowensis Puccinia magnusiana

Puccinia rubella Phryma leptostachya L. Gymnosporium harknessioides

Puccinia phrymae Septoria leptostachyae

Phyllachora graminis (Pers.) Fckl. Piricularia parasitica

Physalis spp.

Cercospora physalidis Entyloma australe Physalis heterophylla Nees.

Entyloma australe Physalis lanceolata Michx.

Entyloma australe Puccinia physalidis

Physalis longifolia Nutt. Mosaic

Physalis pubescens L. Cercospora physalidis Entyloma australe

Physalis pruinosa L. Entyloma australe

Physalis subglabrata Mackenzie & Bush Entyloma australe

Physalis virginiana Mill. Entyloma australe Phytolacca decandra L.

Mosaic

Pilea pumila (L.) Gray Erysiphe cichoracearum Scptoria pileae

Pinus flexilis James Cronartium ribicola Pinus strobus L.

Cronartium ribicola Fusarium spp. Pinus sylvestris L.

Scoleconectria scolecospora

Pisum sativum L. Ascochyta pisi Erysiphe polygoni Fusarium martii var. pisi Peronospora viciae Septoria pisi Plantago spp.

Ramularia plantaginis Plantago aristata Michx. Phomopsis subordinaria Uromyces seditiosus

Plantago major L. Erysiphe cichoracearum Peronospora alta Ramularia plantaginis

Plantago rugelii Dene. Erysiphe cichoracearum Peronospora alta

Platanus sp. Gnomonia veneta

Platanus occidentalis L. Coniothyrium mixtum Cytospora platani Gnomonia veneta Hendersonia desmazierii Massaria platani Myxosporium valsoideum Septoria platanifolia

Pleurotus sp. Sporodinia grandis Poa arachnifera Torr. Erysiphe graminis

Poa compressa L. Scolectotrichum graminis

Poa palustris L. Erysiphe graminis

Poa pratensis L. Cladosporium graminum Cladosporium herbarum Claviceps purpurea Erysiphe graminis Puccinia graminis Puccinia poarum Septoria macropodia Sporotrichum poae

Ustilago striaeformis Podophyllum peltatum L. Puccinia podophyllii Septoria podophyllina

Podosphaera oxyacanthae (DC.) DeB.

Cicinnobolus cesati Polemonium reptans L. Uromyces polemonii Polygala senega L. Aecidium polygalinum Polygonatum biflorum (Walt.) Ell. Puccinia majanthae Polygonatum commutatum (R. & S.) Guignardia polygonati Puccinia majanthae Sphaeropsis cruenta Urocystis colchici Polygonum spp. Cercospora hudropiperis

Melanopsichium austro-americanum

Polygonum acre L. Cercospora hydropiperis

Erysiphe polygoni

Polygonum amphibium var. terrestre Leers Puccinia polygoni-amphibii Polygonum amphibium var. hartwrightii

(Gray) Bissell Puccinia polygoni-amphibii

Polygonum aviculare L. Cercospora avicularis Erysiphe polygoni

Peronospora polygoni Septocylindrium rufomaculans

Uromyces polygoni Ustilago utriculosa

Polygonum convolvulus L. Cercospora polygonacea Peronospora polygoni Puccinia polygoni-amphibii

Polygonum dumetorum L. Peronospora polygoni

Septocylindrium rufomaculans

Polygonum erectum L. Cercospora avicularis Erysiphe polygoni Uromyces polygoni Polygonum hydropiper L. Cercospora hydropiperis Ustilago utriculosa

Polygonum lapathifolium L. Cercospora hydropiperis

Melanopsichium austro-americanum

Septoria polygonorum Ustilago utriculosa

Polygonum muhlenbergii (Meisn.) Wats. Puccinia polygoni-amphibii Septocylindrium rufomaculans

Polygonum pennsylvanicum L.

Septoria polygonorum Ustilago utriculosa Polygonum persicaria L. Septoria polygonorum

Ustilago utriculosa Polygonum ramosissimum Michx.

Cercospora avicularis Erysiphe polygoni Uromyces polygoni Polygonum sagittatum L.

Sphacelotheca hydropiperis

Polygonum scandens L. Peronospora poluaoni Puccinia polygoni-amphibii

Polyporus versicolor L. Hupomuces polyporinus Verticillium agaricinum Polymnia canadensis L.

Puccinia asterum

Populus spp.

Cutospora chrysosperma Discella populina Dothichiza populea Hypoxylon pruinatum Pseudopeziza populi Septoria populi Taphrina aurea

Venturia tremulae Populus alba L. Discella populina Pseudopeziza populi

Populus alba var. nivea Hort.

Pseudopezizza populi

Populus alba L. var. pyramidalis Bunge. Cytospora chryosperma Myxosporium ellisii Pseudomonas tumefaciens

Populus balsamifera L. Melampsora medusae Taphrina aurea

Populus balsamifera suaveolens (Fisch.) Wesm.

Cytospora chrysosperma Populus berolinensis Dipp. Taphrina aurea

Populus canadensis var. eugenei Scheele

Marssonina brunnea Populus candicans Ait. Melampsora medusae Populus deltoides Marsh.

Cytospora chrysosperma Melampsora medusae Uncinula salicis

Venturia tremulae Populus grandidentata Michx. Dicoccum populinum

Uncinula salicis Venturia tremulae

Populus nigra L. var. italica DuRoi Discella populina

Populus occidentalis (Rydb.) Britton Melampsora medusae

Populus sargentii Dode

Melampsora abietis-canadensis

Populus tremuloides Michx. $\overline{H}ypoxylon$ pruinatum Taphrina johansonii Uncinula salicis

Portulaca oleracea L. Albugo portulacae

Potentilla spp. Mollisia dehnii

Peronospora potentillae

Potentilla canadensis L. Phragmidium obtusum Potentilla fruticosa L. Phragmidium andersoni Potentilla monspeliensis L. Mollisia dehnii Peronospora potentillae Ramularia arvensis

Sphaerotheca humuli Potentilla monspeliensis var. norvegica (L.) Ryd.

Peronospora potentillae Potentilla paradoxa Nutt. Phragmidium ivesiae Prenanthes alba L.

Bremia lactucae Septoria nabali

Prenanthes racemosa Michx Septoria nabali

Proserpinaca palustris L. Puccinia proserpinacae Prunella vulgaris L.

Septoria brunellae Sphaerotheca humuli

Prunus spp. Coccomyces lutescens Diaporthe pruni Exoascus mirabilis Exoascus pruni Fomes fulvus Phyllosticta prunicola Phyllosticta virginiana Plowrightia morbosa Podosphaera oxyacanthae Pseudomonas pruni

Pseudomonas tumefaciens Puccinia pruni-spinosae

Sclerotinia fructicola Prunus spp. (plum)

Sclerotinia fructicola Prunus americana Marsh . Cladosporium carpophilum

Coccomyces prunophorae Exoascus mirabilis Exoascus pruni

Phyllosticta prunicola Plowrightia morbosa

Podosphaera oxyacanthae Pseudomonas pruni

Puccinia pruni-spinosae Rhizopus nigricans

Sclerotinia fructicola Septoria pruni

Prunus americana var. chippewa Hort. Puccinia pruni-spinosae

Prunus americana lanata Sudw. Puccinia pruni-spinosae

Prunus angustifolia L. Cladosporium carpophilum Exoascus mirabilis Exoascus pruni

Podosphaera oxyacanthae

Prunus armeniaca L. Coccomyces sp. Plowrightia morbosa

Podosphaera oxyacanthae Pseudomonas pruni

Prunus avium L.

Coccomyces hiemalis Podosphaera oxyacanthae

Prunus besseyi Bailey Pseudomonas pruni Sclerotina fructicola

Prunus cerasus L. Coccomyces hiemalis Podosphaera oxyacanthe Pseudomonas pruni Sclerotinia fructicola Venturia cerasi Winter injury

Prunus domestica L. Coccomyces prunophorae Exoascus pruni Plowrightia morbosa Pseudomonas pruni Puccinia pruni-spinosae

Sclerotinia fructicola Prunus hortulana Bailey Cladosporium carpophilum Diaporthe pruni

Exoascus mirabilis Puccinia pruni-spinosae Sclerotinia fructicola

Prunus instititia L. Plowrightia morbosa

Prunus mahaleb L. Coccomyces lutescens

Prunus munsoniana Wight & Hedr.

Fomes fulvus Pseudomonas pruni Prunus padus L.

Phyllosticta prunicola Plowrightia morbosa

Prunus pennsylvanica L. Coccomyces hiemalis Phyllosticta prunicola

Puccinia pruni-spinosae Prunus persica L.

Cercospora circumscissa Cladosporium carpophilum Exoascus deformans Podosphaera oxyacanthae Pseudomonas pruni Pseudomonas tumefaciens

Puccinia pruni-spinosae Sclerotinia fructicola

Sphaerotheca pannosa Prunus pumila L.

Podosphaera oxyacanthae Prunus pumila L. x P. hortulana mineri Bailey

Sclerotinia fructicola Prunus salicina Lindl. Cladosporium carpophilum Sclerotinia fructicola

Prunus serotina Ehrh. Cercospora circumscissa Coccomyces lutescens Diaporthe pruni Exoascus farlowii Exoascus pruni Phyllosticta prunicola Plowrightia morbosa Puccinia pruni-spinosae Sclerotinia seaveri Prunus tomentosa Thunb. Podosphaera oxyacanthae Prunus virginiana L. Cercospora circumscissa Coccomyces hiemalis Phoma virginiana Phyllosticta destruens Phyllosticta vulgaris Plowrightia morbosa Sclerotinia angustior Psedera quinquefolia (L.) Greene Cercospora ampelopsidis Guignardia bidwellii Plasmopara viticola Septoria ampelopsidis Uncinula necator Psedera quinquefolia var. engelmanii Rehd. Cercospora ampelopsidis Psedera quinquefolia var. hirsuta (Donn.) Rehd. Cercospora ampelopsidis Guignardia bidwellii Psedera tricuspidata Hort. Guignardia bidwellii Septoria ampelopsidis Psedera vitacea (Knerr) Greene Cercospora ampelopsidis Psoralea argophylla Pursh Uromyces argophyllae Ptelea trifoliata L. Cercospora pteleae Pteris aquilina L. Cylindrosporium aquilina Puccinia asparagi DC. Darluca filum Puccinia caricis-asteris Arth. Tuberculina persicina Puccinia eatoniae Arth. Tuberculina persicina Puccinia fraxinata (Schw.) Arth. Tuberculina persicina Puccinia graminis Pers. Darluca filum Fusarium herbarum Puccinia menthae Pers. Fusarium herbarum Puccinia opizii Bubak Tuberculina persicina Puccinia peckii (DeT.) Kellerm.

Tuberculina persicina

Tuberculina persicina

Puccinia phrymae (Halst.) Arth.

Pycnanthemum pilosum Nutt. Puccinia menthae Pycnanthemum virginianum (L.) Durand & Jackson Puccinia menthae Pyrola elliptica Nutt. Melampsora pyrolae Pucciniastrum pyrolae Pyrus sp. Coniothyrium pirinum Pseudomonas tumefaciens Pyrus communis L. Bacillus amylovorus Coniothyrium pirinum Fabraea maculata Mycosphaerella sentina Nummularia discreta Septoria piricola Venturia pyrina Pyrus coronaria L. Gymnosporangium juniperi-virginianae Septoria pyri Pyrus floribunda Lindl. var. atropurpurea Phyllosticta sp. Pyrus ioensis Bailey Bacillus amylovorus Gymnosporangium juniperi-virginianae Phyllosticta zonata Venturia inaequalis Pyrus ioensis var. plena Ar. Venturia inaequalis Pyrus malus L. Apple scald Armillaria mellea Bacillus amylovorus Cercospora pyri Coniothyrium pirinum Fabraea maculata Gloeodes pomigena Glomerella cingulata Gymnosporangium juniperi-virginianae Internal breakdown Jonathan spot Leptothyrium pomi Nummularia discreta Pencillium expansum Phoma pomi Phyllosticta solitaria Physalospora malorum Podosphaera leucotricha Podosphaera oxyacanthae Pseudomonas tumefaciens Sclerotinia fructicola Septoria piricola Septoria pyri Soft scald Venturia inaequalis Winter injury Pyrus prunifolia Willd. Bacillus amylovorus Pyrus serotina Rehd. Bacillus amylovorus

Fabraea maculata

472 Pyrus sieboldii Regel. Podosphaera leucotricha Pyrus soulardi Bailey Venturia inaequalis Quercus sp. Gnomonia veneta Marssonina martini Microsphaera alni Taphrina coerulescens Quercus alba L. Cladosporium herbarum Gnomonia veneta Marssonina martini Microsphaera alni Phyllosticta phomiformis Taphrina coerulescens Quercus ellipsoidalis Hill Actinopelte dryina Quercus macrocarpa Michx. Cronartium quercus Gnomonia veneta Marssonina martini

Phyllosticta phomiformis Quercus palustris Moench. Phyllactinia corylea

Microsphaera alni

Taphrina coerulescens Quercus princides Willd. Microsphaera alni

Quercus robur L. Marssonina martini Microsphaera alni

Quereus rubra L. Actinopelte dryina Marssonina martini Microsphaera alni Phyllactinia corylea Septoria querceti Taphrina coerulescens

Quercus velutina Lam. Microsphaera alni Phyllactinia corylea

Radicula armoracia (L.) Robinson Albugo candida Alternaria herculea Cercospora armoraciae Pseudomonas campestris var. armoraciae

Ramularia armoraciae

Radicula palustris (L.) Moench. Albugo candida

Peronospora lepidii Peronospora parasitica Ramularia armoraciae

Radicula sessiliflora (Nutt.) Greene Albugo candida

Ranunculus spp. Entyloma microsporum Puccinia eatoniae

Ranunculus abortivus L. Erysiphe polygoni Puccinia eatoniae Ramularia ranunculi

Ranunculus delphinifolius Torr. Erysiphe polygoni Ranunculus pennsylvanicus L. Didymaria didyma

Ranunculus recurvatus Poir. Didymaria didyma

Ranunculus septentrionalis Poir. Cercospora ranunculi Didymaria didyma Entyloma microsporum Peronospora ficariae Ramularia aequivoca Ramularia gibba

Raphanus raphanistrum L. Albugo candida

Raphanus sativus L. Actinomyces scabies Albugo candida Aphanomyces raphani Peronospora parasitica Reseda odorata L.

Cercospora rescdae Rhamnus alnifolia L'Her. Puccinia coronata

Rhamnus cathartica L. Puccinia coronata

Rhamnus lanceolata Pursh Puccinia coronata

Rheum rhaponticum L. Ascochyta rhei Colletotrichum erumpens Phyllosticta sphaeropsoidae Pseudomonas tumefaciens Septoria rhaponticae

Rhododendron sp. Exobasidium vaccinii

Rhus canadensis Marsh. var. trilobata (Nutt.) Gray

Verticillium albo-atrum

Rhus glabra L. Botryosphaeria berengeriana Cercospora rhuina Cladosporium aromaticum Cylindrosporium toxicodendri Sphaerotheca humuli Verticillium albo-atrum

Rhus hirta var. dissecta Rehd. Cylindrosporium toxicondendri Sphaerotheca humuli

Rhus radicans L. Uromuces toxicodendri Rhus toxicodendron L. Cercospora toxicodendri Cylindrosporium toxicodendri

Phyllosticta toxica Uromyces toxicodendri

Rhus typhina L. Cylindrosporium toxicodendri Verticillium albo-atrum

Ribes spp. Mycosphaerella fragariae Pleonectria berolinensis Pseudopeziza ribis

Puccinia grossulariae Sphaerotheca mors-uvae Ribes alpinum L.

Puccinia grossulariae

Ribes cynosbati L.

Puccinia grossulariae Sphaerotheca mors-uvae Ribes floridum L'Her,

Pseudopeziza ribis
Puccinia grossulariae
Sphaerotheca mors-uvae

Ribes gracile Michx.

Mycosphaerella grossulariae Phyllosticta grossulariae Pscudopeziza ribis Puccinia grossulariae

Sphaerotheca mors-uvae Ribes grossularia L.

Mycosphaerella grossulariae Plowrightia ribesia Pseudopeziza ribis

Puccinia grossulariae Sphaerotheca mors-uvae

Ribes nigrum L.

Cercospora angulata

Mycosphaerella grossulariae

Ribes odoratum Wendl.

Mycosphaerella aurea
Ribes rotundifolium Michx.
Puccinia grossulariae
Sphaerotheca mors-uvae

Ribes vulgare Lam.
Ccrcospora angulata
Mycosphaerella grossulariae
Sphaerotheca mors-uvae

Rosa spp.

Cereospora rosicola
Coniothyrium rosarum
Diplocarpon rosae
Hyaloceras depazeoides
Peronospora sparsa
Phragmidium amcricanum
Phragmidium disciflorum
Phragmidium speciosum
Polyspora sp.
Pseudomonas tumefaciens
Sphaerotheca humuli
Sphaerotheca pannosa

Rosa blanda Ait.

Cercospora rosicola

Phragmidium americanum

Phragmidium speciosum

Sphaerotheca humuli

Sphaerotheca pannosa

Rosa carolina L.

Cercospora rosicola Rosa multiflora Thunb. Sphaerotheca pannosa

Rosa pratincola arkansana (Greene)

Cercospora rosicola
Phragmidium americanum
Phragmidium rosae-arkansanae
Phragmidium speciosum

Sphaerotheca humuli

Rosa setigera Michx.

Phragmidium disciflorum

Phragmidium rosae-setigerae

Sphaerotheca pannosa Rubus spp.

Gymnoconia interstitialis

Kunkelia nitens

Leptosphaeria coniothyrium

Mosaic

Mycosphaerella rubi Plectodiscella veneta

Pseudomonas tumefaciens

Wind whipping Winter injury

Rubus allegheniensis Porter Gymnoconia interstitialis

Kunkelia nitens Mycosphaerella rubi Phragmidium uredinis Plectodiscella veneta Winter injury

Rubus canadensis L.

Mycosphaerella rubi

Rubus flagellaris Willd.

Mycosphaerella rubi

Rubus idaeus L.
Graphium gracile

Rubus idaeus L. var. aculeatissimus (C. A. Meyer) Regel & Tiling

Phragmidium imitans Plectodiscella veneta

Pucciniastrum americanum

Rubus idaeus L. var. strigosus Maxim. Mosaic

Rubus neglectus Pk.

Plectodiscella veneta

Rubus nigrobaccus Bailey Gloeosporium rubi

Rubus occidentalis L.

Kunkelia nitens

Leptosphaeria coniothyrium Mycosphaerella rubi

Plectodiscella veneta Rubus odoratus L.

Mycosphaerella rubi Rubus strigosus Michx. Phragmidium imitans

Rubus villosus Ait.

Gymnoconia interstitialis Kunkelia nitens

Rudbeckia hirta L.

Erysiphe cichoraccarum

Rudbeckia laciniata L.

Entyloma compositarum Erysiphe cichoracearum Phyllosticta rudbeckiae Plasmopara halstedii

Ramularia rudbeckiae Septoria rudbeckiae Uromyces perigynius

Uromyces perigynius Uromyces rudbeckiae

Rudbeckia laciniata var. hortensia Bailey Uromyces perigynius

Rudbeckia triloba L.

Cercospora tabacina
Plasmopara halstedii
Septoria rudbeckiae
Ruellia ciliosa Pursh
Puccinia ruelliae
Rumex sp.
Ovularia obliqua

Ovularia obliqua Rumex altissimus Wood Ovularia obliqua Puccinia acetosae

Rumex britannica L.

Puccinia acetosae

Ramularia pratensis

Rumex crispus L.
Ovularia obliqua
Pscudomonas tumefaciens
Ramularia decipiens

Rumex patientia L.
Ovularia obliqua

Rumex verticillatus L. Ramularia decipiens

Russula sp.
Nyctalis asterophora

Saccharum officinarum L. Mosaic

Sagittaria latifolia Willd.
Cercospora sagittariae
Doassansia deformans
Doassansia intermedia
Gloeosporium confluens

Salix spp.
Cylindrosporium salicinum
Melampsora bigelowii
Melampsora humboldtiana
Rhytisma salicinum

Salix amydaloides Anderson Melampsora bigelowii Uncinula salicis

Salix babylonica L.

Cytospora chrysosperma
Salix bebbiana Sarg.

Melampsora humboldtiana Salix cordata Muhl.

Melampsora humboldtiana Uncinula salicis

Salix discolor Muhl.
Uncinula salicis

Salix fragilis L.

Melampsora humboldtiana
Salix humulis Marsh.

Melampsora humboldtiana
Uncinula salicis

Salix interior Rowlee

Melampsora humboldtiana
Uncinula salicis

Uncinula salicis Salix lucida Muhl.

Melampsora humboldtiana Salix nigra Marsh. Melampsora humboldtiana

Salix pentandra L. Cylindrosporium salicinum

Salix purpurea L.

Cytospora salicis
Salix vitellina L.

Cylindrosporium salicinum

Salvia lanceaefolia Poir.

Peronospora lamii

Puccinia caulicola

Sambueus sp.

Microsphaera alni Sambucus canadensis L. Cercospora depazeoides Microsphaera grossulariae

Microsphaera grossulariae Puccinia sambuci Septoria sambucina Sambucus laciniata Mill.

Cercospora depazeoides Sambucus nigra L.

Cercospora depazeoides Sambucus racemosa L.

Sambucus racemosa L.
Cercospora depazeoides
Cercospora lateritia
Septoria sambucina

Sanguisorba canadensis L. Podosphaera oxyacanthae Sanicula sp.

Entyloma saniculae

Sanicula canadensis Torr. Entyloma saniculae

Sanicula marilandica L.
Entyloma saniculae
Puccinia marylandica
Septoria saniculae
Urophlyctis pluriannulata

Crophlyctis pluriannulate Scirpus atrovirens Muhl. Puccinia angustata

Uromyces scirpi Scirpus cyperinus (L.) Kunth. Puccinia angustata

Scirpus fluviatilis (Torr.) Gray
Uromyces scirpi

Scirpus validus Vahl.

Puccinia obtecta

Scrophularia leporella Bicknell Septoria scrophulariae

Scrophularia marilandica L.

Peronospora sordida
Septoria scrophulariae

Scutellaria galericuta L.

Erysiphe galeopsidis

Santallaria lateridam I

Scutellaria lateriflora L.
Erysiphe cichoracearum
Erysiphe galeopsidis
Septoria scutellariae

Scutcharia versicolor L.

Septoria scutellariae

Secale cereale L.
Claviceps purpurea
Colletotrichum graminicolum
Erysiphe graminis
Gibberella saubinetii
Puccinia dispersa
Puccinia graminis

Septoria secalis Urocystis occulta Sedum spectabile Boreau. Septoria sedi

Sedum spectabile var. brilliant Hort. Septoria sedi

Sedum spectabile var. variegata Hort. Septoria sedi

Senecio aureus L. Puccinia eriophori

Setaria glauca (L.) Beauv. Cercospora setariae Piricularia grisea Pseudomonas holci Sclerospora graminicola

Ustilago neglecta

Setaria italica (L.) Beauv. Cladosporium sp. Piricularia grisea Sclerospora graminicola Ustilago crameri

Setaria viridis (L.) Beauv. Piricularia grisea Sclerospora graminicola Ustilago neglecta

Silene antirrhina L. Peronospora arenariae Septoria silenes

Silene nivea (Nutt.) Arth. Uromyces silenes Silene stellata (L.) Ait.

Septoria silenes

Silphium integrifolium Michx. Puccinia silphii

Silphium laciniatum L. Coleosporium terebinthinaceae Plasmopara halstedii Puccinia silphii Uromyces silphii

Silphium perfoliatum L. Colletotrichum silphii Plasmopara halstedii Puccinia silphii Septoria silphii Uromyces silphii

Sisymbrium altissimum L. Albugo candida

Sisymbrium canescens Nutt. Albugo candida

Peronospora parasitica Sisymbrium officinale (L.) Scop. Albugo candida

Peronospora parasitica Sium cicutaefolium Schrank.

Cercospora sii Smilacina racemosa (L.) Desf.

Puccinia majanthae Septoria smilacinae Sphaeropsis cruenta

Smilacina stellata (L.) Desf. Septoria smilacinae

Smilax spp.

Cercospora smilacis Ramularia subrufa

Smilax herbacea L. Sphaeropsis cruenta

Smilax hispida Muhl. Cercospora smilacis Sphaeropsis cruenta

Smilax rotundifolia L. Sphaeropsis cruenta

Soja max Piper Mosaic

Pseudomonas phaseoli sojense

Solanum carolinense L. Erysiphe cichoracearum Solanum dulcamara L.

Mosaic

Solanum melongena L. Glomerella cingulata Mosaic

Phomopsis vexans Solanum nigrum L.

Entyloma australe Solanum tuberosum L. Actinomyces scabies Alternaria solani

Bacillus atrosepticus Cercospora concors

Corticium vagum Curly dwarf Fusarium sp.

Fusarium eumartii Fusarium oxysporum Fusarium radicicola Fusarium trichothecioides

Hopper burn Mosaic

Phytophthora infestans Pseudomonas solanacearum Rhizopus nigricans

Spindle tuber Spondylocladium atrovirens

Solidago spp. Erysiphe cichoracearum Puccinia asterum Septoria fumosa

Solidago altissima L. Coleosporium solidaginis Puccinia asterum

Solidago canadensis L. Coleosporium solidaginis Erysiphe cichoracearum Phyllachora haydeni Puccinia asterum Septoria solidaginis

Septoria virgaureae Solidago glaberrima Martens Coleosporium solidaginis Puccinia asterum

Solidago graminifolia (L.) Salisb. Rhytisma solidaginis

Spiraea sp.

476 Solidago latifolia L. Cercospora stomatica Cercosporella virgaureae Coleosporium solidaginis Phyllosticta gallicola Puccinia asterum Rhytisma solidaginis Solidago nemoralis Ait. Coleosporium solidaginis Puccinia grindeliae Solidago rigida L. Erysiphe cichoracearum Puccinia asterum Solidago serotina Ait. Cercosporella virgaureae Coleosporium solidaginis Erysiphe cichoracearum Puccinia asterum Septoria virgaureae Solidago serotina var. gigantea (Ait.) Gray Erysiphe cichoracearum Solidago speciosa Nutt. Coleosporium solidaginis Septoria virgaureae Solidago ulmifolia Muhl. Coleosporium solidaginis Puccinia asterum Sonchus oleraceus L. Sphaerotheca humuli Sorbus sp. Nummularia discreta Sorbus aucuparia L. Cytospora rubescens Mycosphaerella aucupariae Nummularia discreta Phyllosticta sorbi Sorbus americana Marsh. Alternaria sp. Phyllosticta sorbi Sorghastrum nutans (L.) Nash Phyllachora graminis Sparganium eurycarpum Engelm. Uromyces sparganii Spartina michauxiana Hitchc. Claviceps purpurea Puccinia cephalanthi Puccinia distichlidis Puccinia fraxinata Puccinia seymouriana Uromyces polemonii Specularia perfoliata L. Septoria speculariae Sphenopholis obtusata (Michx.) Scribn. Erysiphe graminis

Puccinia eatoniae

Puccinia eatoniae

Peronospora effusa

Spinacia oleracea L.

Sphenopholis pallens (Spreng.) Scribn.

Cylindrosporium filipendulae Spiraea billardii Herincq. Cylindrosporium filipendulae Spiraea douglasii Hook. Cylindrosporium filipendulae Spiraea margarita Cy. Cylindrosporium filipendulae Spireae salicifolia L. Podosphaera oxyacanthae Spiraea thunbergii Sicb. Cylindrosporium filipendulae Spiraea vanhouttei Zabel Cylindrosporium filipendulae Sporobolus asper (Michx.) Kunth. Puccinia sporoboli Puccinia verbenicola Sporobolus brevifolius (Nutt.) Scribn. Phyllachora vulgata Puccinia sporoboli Sporobolus cryptandrus (Torr.) Gray Puccinia sporoboli Uromyces allicolus Sporobolus heterolepis Gray $Puccinia\ sporoboli$ Sporobolus neglectus Nash Puccinia sporoboli Puccinia verbenicola Uromyces allicolus Ustilago vilfae Sporobolus vaginiflorus (Torr.) Wood Puccinia sporoboli Stachys palustris L. Cercospora stachydis Erysiphe galeopsidis Stachys tenuifolia Willd. Septoria stachydis Staphylea trifolia L. Ovularia isarioides Steironema ciliatum (L.) Raf. Puccinia dayii Septoria conspicua Uromyces polemonii Steironema quadriflorum (Sims) Hitchc. Septoria conspicua Stipa spartea Trin. Puccinia stipae Ustilago hypodytes Ustilago minima Stokesia laevis Greene Mosaic Strophostyles helvola (L.) Britt. Erysiphe polygoni Phyllosticta phaseolina Uromyces appendiculatus Strophostyles pauciflora (Benth.) Wats. Uromyces appendiculatus Symphoricarpos albus var. laevigatus (Fern.) Blake Sphaceloma symphoricarpi Symphoricarpos occidentalis Hook. Cercospora symphoricarpi

Microsphaera diffusa Septoria symphoricarpi

Symphoricarpos orbiculatus Moench. Microsphaera diffusa Puccinia abundans

Symphoricarpos racemosus Michx. Microsphaera diffusa

Phoma bacciola

Symphoricarpos vulgaris var. variegatus

Microsphaera diffusa

Syringa sp. Alternaria sp.

Cercospora macromaculans

Syringa persica L. Microsphaera alni Syringa vulgaris L.

Microsphaera alni

Taraxacum erythrospermum Andrz. Ramularia taraxaci

Taraxacum officinale Weber Erysiphe cichoracearum Puccinia hieracii Ramularia taraxaci Sphaerotheca humuli

Tecoma radicans (L.) Juss.

Cercospora sordida Teucrium canadense L. Cercospora racemosa Cercospora teucrii Erysiphe galeopsidis Gymnosporium harknessioides Phyllosticta teucrii

Thalictrum dasyearpum Fisch. & Lall.

Puccinia clematidis Puccinia pruni-spinosae Thalictrum dioicum L. Mycosphaerella thalictri Puccinia clematidis Puccinia pruni-spinosae Puccinia thalictri

Thalictrum polygamum Muhl. Mycosphaerella thalictri Puccinia clematidis Puccinia pruni-spinosae Puccinia thalictri

Thalietrum revolutum DC. Erysiphe polygoni

Tilia sp.

Cercospora microsora Tilia americana L.

Cercospora microsora Gnomonia tiliae

Rabenhorstia tiliae Uncinula clintoni

Tradescantia bracteata Small Cylindrosporium tradescantiae Tragopogon porrifolius L.

Albugo tragopogonis Erysiphe cichoracearum Tragopogon pratensis L. Erysiphe cichoracearum Trifolium spp. Colletotrichum trifolii

Dothidella trifolii Gloeosporium trifolii Trifolium hybridum L.

Uromyces trifolii-repentis Trifolium incarnatum L.

Pseudomonas trifoliorum Uromyces trifolii-repentis

Trifolium medium L. Pseudomonas trifoliorum

Trifolium pratense L. Cercospora zebrina Dothidella trifolii Erysiphe polygoni Glocosporium caulivorum Mosaic Pseudomonas trifoliorum

Pseudopeziza trifolii Uromyces fallens Trifolium repens L.

Cercospora zebrina Dothidella trifolii Pseudomonas trifoliorum Uromyces trifolii-repentis

Triosteum perfoliatum L. Cladosporium triostei

Triplasis purpurea (Walt.) Chapm. Ustilago sieglingiae

Tripsacum dactyloides L. Puccinia polysora Triticum polonicum L. Puccinia graminis

Triticum vulgare Vill. Cladosporium graminum Claviceps purpurea Colletotrichum graminicolum Erysiphe graminis

Fusarium culmorum Gibberella saubinetii Helminthosporium sativum Leptosphaeria tritici Phyllachora graminis

Pseudomonas translucens var. undu-

Puccinia clematidis Puccinia graminis Septoria nodorum Septoria tritici Tilletia foetens Tilletia tritici Ustilago tritici

Ulmus spp. Gnomonia ulmea Pleurotus ulmarius

Ulmus americana L. Gnomonia ulmea Microsphaera alni Phyllactinia corylea Phyllosticta melaleuca Physalospora malorum Sphaeropsis ulmicola Uncinula macrospora

Ulmus fulva L.

Mycosphaerella ulmi
Gnomonia ulmea
Ulmus racemosa Thomas

Phyllactinia corylea
Uncinula macrospora

Urtica sp.

Puccinia urticae

Urtica gracilis Ait.

Puccinia urticae

Ramularia urticae

Septoria urticae

Uromyces silphii (Burr.) Arth.

Darluca filum

Uvularia grandiflora Smith Phyllosticta discincta Puccinia majanthae

Verbaseum sp.

Ramularia variabilis

Verbascum thapsus L.

Cercospora verbascicola
Ramularia variabilis

Verbena bracteosa Michx.

Erysiphe cichoracearum Verbena hastata L.

Erysiphe cichoracearum Septoria verbenae

Verbena stricta Vent.

Erysiphe cichoracearum
Puccinia verbenicola

Verbena urticaefolia L.

Erysiphe cichoracearum

Mosaic

Puccinia verbenicola Septoria verbenae

Verbesina spp.

Erysiphe cichoracearum
Verbesina helianthoides Michx.
Erysiphe cichoracearum

Vernonia sp.

Vernoma sp.
Coleosporium carneum

Vernonia altissima Nutt.

Cercospora oculata

Vernonia baldwini Torr. Cercospora vernoniae Coleosporium carneum

Coleosporium carneu
Puccinia vernoniae

Vernonia fasciculata Michx.
Cercospora vernoniae
Coleosporium carncum
Erysiphe cichoracearum
Mosaic

Puccinia vernoniae Vernonia noveboracensis Willd.

Puccinia vernoniae Veronica peregrina L.

Entyloma linariae Veronica serpyllifolia L. Puccinia veronicarum

Veronica virginica L.
Puccinia veronicarum

Septoria veronicae Sphaerotheca humuli

Viburnum sp.

Microsphaera alni Viburnum lentago L.

Cercospora opuli Cercospora varia Coleosporium viburni Hendersonia viburni

Hendersonia viburn Microsphaera alni

Viburnum opulus L. Cercospora opuli

Viburnum opulus var. sterile DC.

Cercospora opuli Viburnum pubescens Ait.

Microsphaera alni Viburnum trilobum Marsh.

Cercospora opuli

Vicia sp.

Microsphaera alni

Vicia americana Muhl.
Peronospora viciae
Uromyces fabae
Uromyces porosus

Vicia sativa L.

Cercospora viciae Vicia sparsifolia Nutt.

Uromyces porosus Vigna sinensis Endl.

Vigna sinensis Endi.
Bacillus sp.
Erysiphe polygoni
Mosaic
Phullosticta phascolina

Uromyces appendiculatus Viola spp.

Cercospora granuliformis
Cercospora violae

Marssonina violae Peronospora violae Phyllosticta violae

Puccinia violae

Viola cornuta L. Sphaerotheca humuli

Viola cucullata Ait.
Cercospora granuliformis

Cercospora violae Colletotrichum violae-tricoloris

Marssonina violae Puccinia violae

Viola eriocarpa Schw. Puccinia violae

Viola obliqua Hill

Cercospora granuliformis

Phyllosticta violae

Puccinia violae Viola palmata L.

Puccinia ellisiana

Viola papilionacea Pursh Cercospora granuliformis Puccinia ellisiana

Puccinia violae

Viola pedata L.

Puccinia ellisiana

Viola pedatifida G. Don. Puccinia ellisiana

Viola pubescens Ait. Ascochuta violae Cercospora granuliformis Phyllosticta violae Puccinia violae

Viola scabriuscula Schw. Puccinia violae

Viola sororia Willd.

Puccinia violae

Viola tricolor var. hortensis DC. Sphaerotheca humuli

Vitis spp. Cryptosporella viticola Gloeosporium ampelophagum Guignardia bidwellii Plasmopara viticola Pseudomonas tumefaciens Uncinula necator

Vitis sp. (cult.) Plasmopara viticola

Vitis aestivalis Michx.

Guignardia bidwellii Vitis bicolor LeConte Plasmopara viticola

Vitis cordifolia Michx. Uncinula necator

Vitis labrusca L. Gloeosporium ampelophagum Guignardia bidwellii Plasmopara viticola

Uncinula necator Vitis labruscana Bailey Gloeosporium ampelophagum Guignardia bidwellii Plasmopara viticola

Uncinula necator Vitis riparia L.

Plasmopara viticola Vitis rotundifolia Michx.

Guignardia bidwellii Uncinula necator

Vitis vinifera L. Cercospora viticola Uncinula necator

Vitis vulpina L. Guignardia bidwellii Plasmopara viticola Septoria ampelina Uncinula necator

White Grub Cordyceps herculea Cordyceps militaris Cordyceps ravenellii

Xanthium spp. Puccinia canaliculata

Xanthium canadense Mill. Erysiphe cichoracearum Plasmopara halstedii Puccinia xanthii

Xanthium commune Britton Puccinia xanthii Xanthium echinatum Murr.

Puccinia xanthii

Xanthium italicum Mor. Puccinia xanthii

Yucca filamentosa L. Coniothyrium concentricum Kellermania yuccagena

Yucca gloriosa L. Cercospora concentrica Neottiospora sp.

Zanthoxylum americanum Mill. Aecidium xanthoxyli Phyllactinia corylea

Septoria pachyspora

Zea mays L. Bacterium stewarti Basisporium gallarum Cephalosporium acremonium Cladosporium herbarum Diplodia zeae Fusarium spp. Gibberella moniliformis Gibberella saubinetii Helminthosporium turcicum Mosaic Physoderma zeae-maydis Pseudomonas holci Puccinia sorghi

Sclerospora graminicola Sorosporium reilianum Ustilago zeae

Zea mays var. everta Bailey Puccinia sorghi Sclerospora graminicola Ustilago zeae

Zea mays var. indentata Bailey Pseudomonas holci Puccinia sorghi Ustilago zeae

Zea mays var. rugosa Bonaf. Bacterium stewarti Rasisporium gallarum Puccinia sorghi Sclerospora graminicola Ustilago zeae

Zinnia sp. Erysiphe cichoracearum Zinnia elegans Jacq.

Mosaic Zizania aquatica L. Claviceps sp.

Entyloma lineatum Zizia aurea (L.) Koch. Urophlyctis pluriannulata

Zygadenus chloranthus Richards Puccinia atropuncta Uromyces zygadeni

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